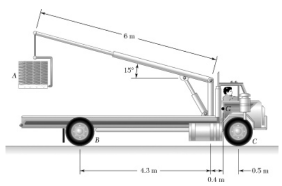
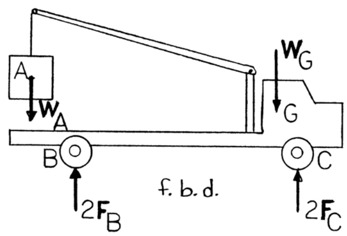


PROBLEM 4.1

The boom on a 4300-kg truck is used to unload a pallet of shingles of mass 1600 kg. Determine the reaction at each of the two (*a*) rear wheels *B*, (*b*) front wheels *C*.

SOLUTION



$$W_A = m_A g = (1600\text{ kg})(9.81\text{ m/s}^2)$$

$$= 15696\text{ N}$$

or $$\mathbf{W}_A = 15.696\text{ kN}\downarrow$$

$$W_G = m_G g = (4300\text{ kg})(9.81\text{ m/s}^2)$$

$$= 42\,183\text{ N}$$

or $$\mathbf{W}_G = 42.183\text{ kN}\downarrow$$

(*a*) From f.b.d. of truck with boom

$$+\circlearrowright \Sigma M_C = 0{:}\quad (15.696\text{ kN})\left[(0.5 + 0.4 + 6\cos 15°)\text{ m}\right] - 2F_B\left[(0.5 + 0.4 + 4.3)\text{ m}\right]$$

$$+ (42.183\text{ kN})(0.5\text{ m}) = 0$$

$$\therefore\ 2F_B = \frac{126.185}{5.2} = 24.266\text{ kN}$$

or $\mathbf{F}_B = 12.13\text{ kN}\uparrow$ ◀

(*b*) From f.b.d. of truck with boom

$$+\circlearrowright \Sigma M_B = 0{:}\quad (15.696\text{ kN})\left[(6\cos 15° - 4.3)\text{ m}\right] - (42.183\text{ kN})\left[(4.3 + 0.4)\text{ m}\right]$$

$$+ 2F_C\left[(4.3 + 0.9)\text{ m}\right] = 0$$

$$\therefore\ 2F_C = \frac{174.786}{5.2} = 33.613\text{ kN}$$

or $\mathbf{F}_C = 16.81\text{ kN}\uparrow$ ◀

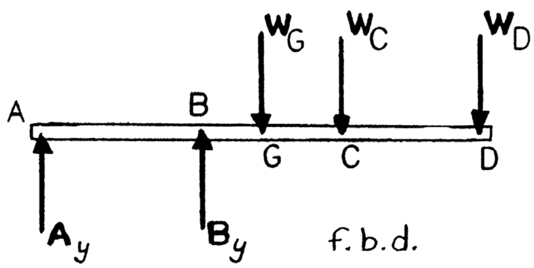
Check: $$+\uparrow \Sigma F_y = 0{:}\quad (33.613 - 42.183 + 24.266 - 15.696)\text{ kN} = 0?$$

$$(57.879 - 57.879)\text{ kN} = 0\ \text{ ok}$$

PROBLEM 4.2

Two children are standing on a diving board of mass 65 kg. Knowing that the masses of the children at C and D are 28 kg and 40 kg, respectively, determine (a) the reaction at A, (b) the reaction at B.

SOLUTION



$$W_G = m_G g = (65\text{ kg})(9.81\text{ m/s}^2) = 637.65\text{ N}$$

$$W_C = m_C g = (28\text{ kg})(9.81\text{ m/s}^2) = 274.68\text{ N}$$

$$W_D = m_D g = (40\text{ kg})(9.81\text{ m/s}^2) = 392.4\text{ N}$$

(a) From f.b.d. of diving board

$$+\circlearrowleft\ \Sigma M_B = 0: \quad -A_y(1.2\text{ m}) - (637.65\text{ N})(0.48\text{ m}) - (274.68\text{ N})(1.08\text{ m}) - (392.4\text{ N})(2.08\text{ m}) = 0$$

$$\therefore\ A_y = -\frac{1418.92}{1.2} = -1182.43\text{ N}$$

or $\mathbf{A}_y = 1.182\text{ kN}\downarrow$ ◀

(b) From f.b.d. of diving board

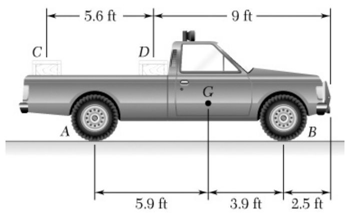
$$+\circlearrowleft\ \Sigma M_A = 0: \quad B_y(1.2\text{ m}) - 637.65\text{ N}(1.68\text{ m}) - 274.68\text{ N}(2.28\text{ m}) - 392.4\text{ N}(3.28\text{ m}) = 0$$

$$\therefore\ B_y = \frac{2984.6}{1.2} = 2487.2\text{ N}$$

or $\mathbf{B}_y = 2.49\text{ kN}\uparrow$ ◀

Check: $\quad +\uparrow\ \Sigma F_y = 0: \quad (-1182.43 + 2487.2 - 637.65 - 274.68 - 392.4)\text{ N} = 0?$

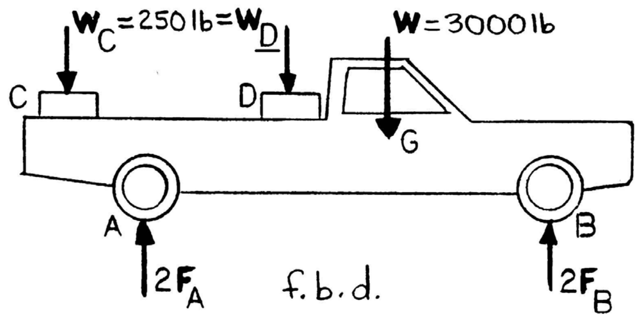
$$(2487.2 - 2487.2)\text{ N} = 0 \text{ ok}$$



PROBLEM 4.3

Two crates, each weighing 250 lb, are placed as shown in the bed of a 3000-lb pickup truck. Determine the reactions at each of the two (*a*) rear wheels *A*, (*b*) front wheels *B*.

SOLUTION



(*a*) From f.b.d. of truck

$$+\circlearrowleft \Sigma M_B = 0: \quad (250\text{ lb})(12.1\text{ ft}) + (250\text{ lb})(6.5\text{ ft}) + (3000\text{ lb})(3.9\text{ ft}) - (2F_A)(9.8\text{ ft}) = 0$$

$$\therefore\ 2F_A = \frac{16350}{9.8} = 1668.37\text{ lb}$$

$$\therefore\ \mathbf{F}_A = 834\text{ lb} \uparrow \blacktriangleleft$$

(*b*) From f.b.d. of truck

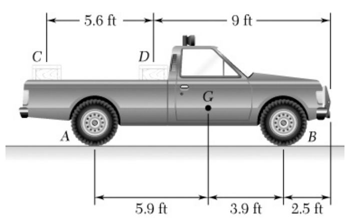
$$+\circlearrowleft \Sigma M_A = 0: \quad (2F_B)(9.8\text{ ft}) - (3000\text{ lb})(5.9\text{ ft}) - (250\text{ lb})(3.3\text{ ft}) + (250\text{ lb})(2.3\text{ ft}) = 0$$

$$\therefore\ 2F_B = \frac{17950}{9.8} = 1831.63\text{ lb}$$

$$\therefore\ \mathbf{F}_B = 916\text{ lb} \uparrow \blacktriangleleft$$

Check: $+\uparrow \Sigma F_y = 0: \quad (-250 + 1668.37 - 250 - 3000 + 1831.63)\text{ lb} = 0?$

$$(3500 - 3500)\text{ lb} = 0 \ \text{ ok}$$

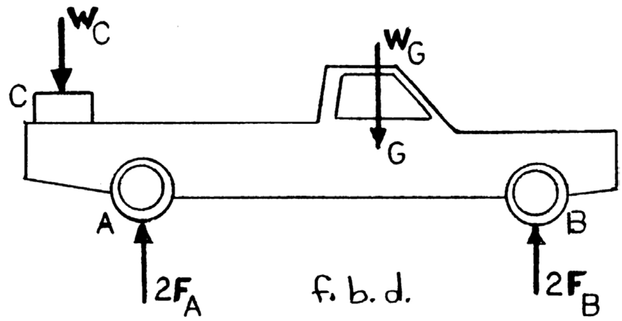


PROBLEM 4.4

Solve Problem 4.3 assuming that crate *D* is removed and that the position of crate *C* is unchanged.

P4.3 The boom on a 4300-kg truck is used to unload a pallet of shingles of mass 1600 kg. Determine the reaction at each of the two (*a*) rear wheels *B*, (*b*) front wheels *C*

SOLUTION



(*a*) From f.b.d. of truck

$$+\circlearrowright \Sigma M_B = 0: \quad (3000\text{ lb})(3.9\text{ ft}) - (2F_A)(9.8\text{ ft}) + (250\text{ lb})(12.1\text{ ft}) = 0$$

$$\therefore \ 2F_A = \frac{14725}{9.8} = 1502.55\text{ lb}$$

or $\mathbf{F}_A = 751\text{ lb}\uparrow$ ◀

(*b*) From f.b.d. of truck

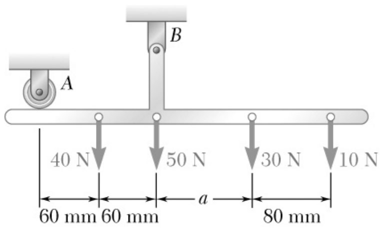
$$+\circlearrowright \Sigma M_A = 0: \quad (2F_B)(9.8\text{ ft}) - (3000\text{ lb})(5.9\text{ ft}) + (250\text{ lb})(2.3\text{ ft}) = 0$$

$$\therefore \ 2F_B = \frac{17125}{9.8} = 1747.45\text{ lb}$$

or $\mathbf{F}_B = 874\text{ lb}\uparrow$ ◀

Check: $+\uparrow \Sigma F_y = 0: \quad \left[2(751 + 874) - 3000 - 250\right]\text{lb} = 0?$

$$(3250 - 3250)\text{ lb} = 0 \ \text{ ok}$$

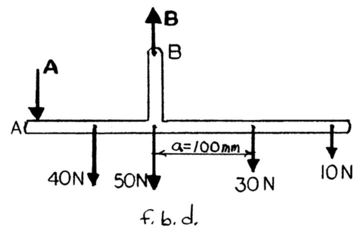


PROBLEM 4.5

A T-shaped bracket supports the four loads shown. Determine the reactions at A and B if (a) $a = 100$ mm, (b) $a = 70$ mm.

SOLUTION

(a)



From f.b.d. of bracket

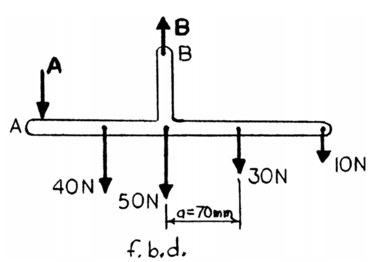
$$+\circlearrowleft \Sigma M_B = 0: \quad -(10\text{ N})(0.18\text{ m}) - (30\text{ N})(0.1\text{ m}) + (40\text{ N})(0.06\text{ m}) + A(0.12\text{ m}) = 0$$

$$\therefore\ A = \frac{2.400}{0.12} = 20\text{ N} \qquad \text{or } \mathbf{A} = 20.0\text{ N} \downarrow \blacktriangleleft$$

$$+\circlearrowleft \Sigma M_A = 0: \quad B(0.12\text{ m}) - (40\text{ N})(0.06\text{ m}) - (50\text{ N})(0.12\text{ m}) - (30\text{ N})(0.22\text{ m}) - (10\text{ N})(0.3\text{ m}) = 0$$

$$\therefore\ B = \frac{18.000}{0.12} = 150\text{ N} \qquad \text{or } \mathbf{B} = 150.0\text{ N} \uparrow \blacktriangleleft$$

(b)



From f.b.d. of bracket

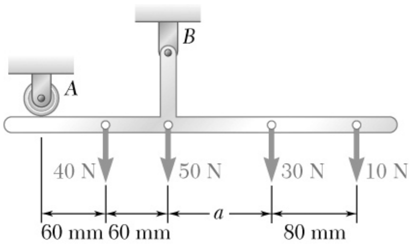
$$+\circlearrowleft \Sigma M_B = 0: \quad -(10\text{ N})(0.15\text{ m}) - (30\text{ N})(0.07\text{ m}) + (40\text{ N})(0.06\text{ m}) + A(0.12\text{ m}) = 0$$

$$\therefore\ A = \frac{1.200}{0.12} = 10\text{ N} \qquad \text{or } \mathbf{A} = 10.00\text{ N} \downarrow \blacktriangleleft$$

$$+\circlearrowleft \Sigma M_A = 0: \quad B(0.12\text{ m}) - (40\text{ N})(0.06\text{ m}) - (50\text{ N})(0.12\text{ m}) - (30\text{ N})(0.19\text{ m})$$

$$-(10\text{ N})(0.27\text{ m}) = 0$$

$$\therefore\ B = \frac{16.800}{0.12} = 140\text{ N} \qquad \text{or } \mathbf{B} = 140.0\text{ N} \uparrow \blacktriangleleft$$

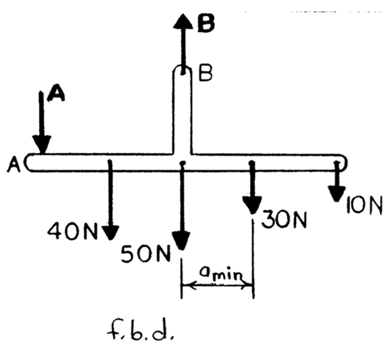


PROBLEM 4.6

For the bracket and loading of Problem 4.5, determine the smallest distance a if the bracket is not to move.

P4.5 A T-shaped bracket supports the four loads shown. Determine the reactions at A and B if (a) $a = 100$ mm, (b) $a = 70$ mm.

SOLUTION



The $a_{\min}$ value will be based on $\mathbf{A} = 0$

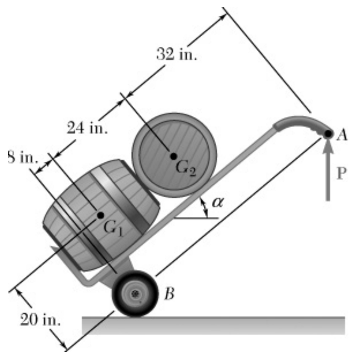
From f.b.d. of bracket

$$+\circlearrowleft\ \Sigma M_B = 0: \quad (40\text{ N})(60\text{ mm}) - (30\text{ N})(a) - (10\text{ N})(a + 80\text{ mm}) = 0$$

$$\therefore\ a = \frac{1600}{40} = 40\text{ mm}$$

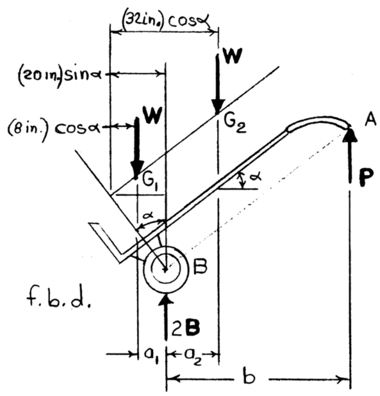
or $a_{\min} = 40.0$ mm ◀

PROBLEM 4.7



A hand truck is used to move two barrels, each weighing 80 lb. Neglecting the weight of the hand truck, determine (*a*) the vertical force **P** which should be applied to the handle to maintain equilibrium when $\alpha = 35^\circ$, (*b*) the corresponding reaction at each of the two wheels.

SOLUTION



$$a_1 = (20\text{ in.})\sin\alpha - (8\text{ in.})\cos\alpha$$

$$a_2 = (32\text{ in.})\cos\alpha - (20\text{ in.})\sin\alpha$$

$$b = (64\text{ in.})\cos\alpha$$

From f.b.d. of hand truck

$$+\circlearrowleft \Sigma M_B = 0: \quad P(b) - W(a_2) + W(a_1) = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad P - 2w + 2B = 0 \qquad (2)$$

For $\alpha = 35^\circ$

$$a_1 = 20\sin 35^\circ - 8\cos 35^\circ = 4.9183\text{ in.}$$

$$a_2 = 32\cos 35^\circ - 20\sin 35^\circ = 14.7413\text{ in.}$$

$$b = 64\cos 35^\circ = 52.426\text{ in.}$$

(*a*) From Equation (1)

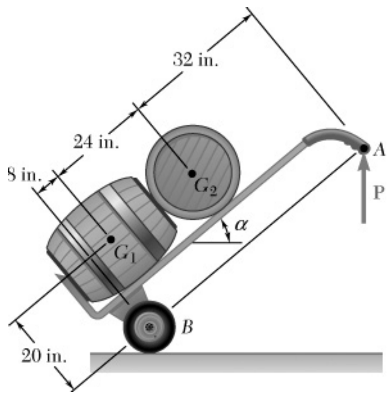
$$P(52.426\text{ in.}) - 80\text{ lb}(14.7413\text{ in.}) + 80\text{ lb}(4.9183\text{ in.}) = 0$$

$\therefore\ P = 14.9896\text{ lb}$ or $\mathbf{P} = 14.99\text{ lb}\uparrow$ ◀

(*b*) From Equation (2)

$$14.9896\text{ lb} - 2(80\text{ lb}) + 2B = 0$$

$\therefore\ B = 72.505\text{ lb}$ or $\mathbf{B} = 72.5\text{ lb}\uparrow$ ◀

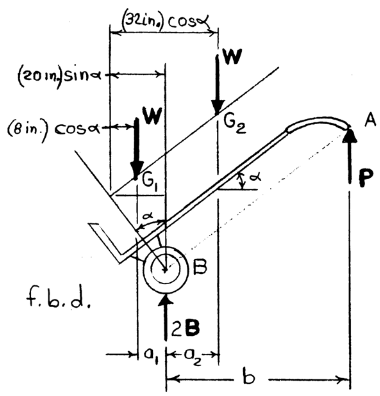


PROBLEM 4.8

Solve Problem 4.7 when $\alpha = 40^\circ$.

P4.7 A hand truck is used to move two barrels, each weighing 80 lb. Neglecting the weight of the hand truck, determine (*a*) the vertical force **P** which should be applied to the handle to maintain equilibrium when $\alpha = 35^\circ$, (*b*) the corresponding reaction at each of the two wheels.

SOLUTION



$$a_1 = (20\text{ in.})\sin\alpha - (8\text{ in.})\cos\alpha$$

$$a_2 = (32\text{ in.})\cos\alpha - (20\text{ in.})\sin\alpha$$

$$b = (64\text{ in.})\cos\alpha$$

From f.b.d. of hand truck

$$+\circlearrowleft\ \Sigma M_B = 0: \quad P(b) - W(a_2) + W(a_1) = 0 \qquad (1)$$

$$+\uparrow\ \Sigma F_y = 0: \quad P - 2w + 2B = 0 \qquad (2)$$

For $\qquad \alpha = 40^\circ$

$$a_1 = 20\sin 40^\circ - 8\cos 40^\circ = 6.7274\text{ in.}$$

$$a_2 = 32\cos 40^\circ - 20\sin 40^\circ = 11.6577\text{ in.}$$

$$b = 64\cos 40^\circ = 49.027\text{ in.}$$

(*a*) From Equation (1)

$$P(49.027\text{ in.}) - 80\text{ lb}(11.6577\text{ in.}) + 80\text{ lb}(6.7274\text{ in.}) = 0$$

$$\therefore\ P = 8.0450\text{ lb}$$

or $\mathbf{P} = 8.05\text{ lb}\uparrow$ ◀

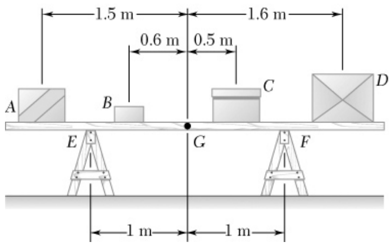
(*b*) From Equation (2)

$$8.0450\text{ lb} - 2(80\text{ lb}) + 2B = 0$$

$$\therefore\ B = 75.9775\text{ lb}$$

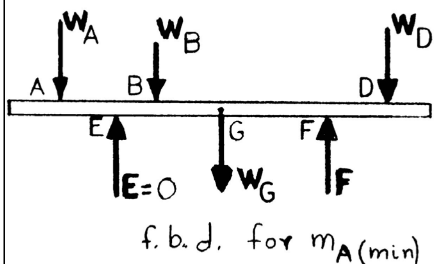
or $\mathbf{B} = 76.0\text{ lb}\uparrow$ ◀

PROBLEM 4.9



Four boxes are placed on a uniform 14-kg wooden plank which rests on two sawhorses. Knowing that the masses of boxes *B* and *D* are 4.5 kg and 45 kg, respectively, determine the range of values of the mass of box *A* so that the plank remains in equilibrium when box *C* is removed.

SOLUTION



$$W_A = m_A g \qquad W_D = m_D g = 45\,g$$

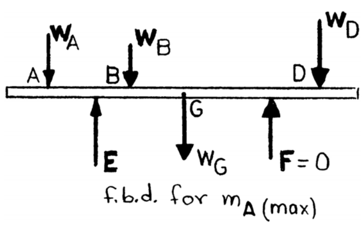
$$W_B = m_B g = 4.5g \qquad W_G = m_G g = 14g$$

For $(m_A)_{\min}$, $E = 0$

$$+\circlearrowleft \Sigma M_F = 0: \quad (m_A g)(2.5\text{ m}) + (4.5g)(1.6\text{ m})$$

$$+(14g)(1\text{ m}) - (45g)(0.6\text{ m}) = 0$$

$$\therefore\ m_A = 2.32\text{ kg}$$



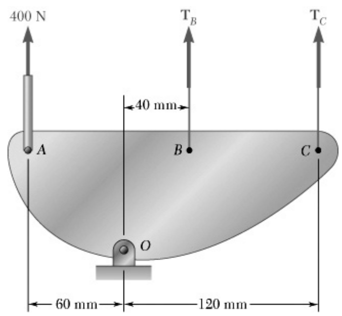
For $(m_A)_{\max}$, $F = 0$:

$$+\circlearrowleft \Sigma M_E = 0: \quad m_A g(0.5\text{ m}) - (4.5g)(0.4\text{ m}) - (14g)(1\text{ m})$$

$$-(45g)(2.6\text{ m}) = 0$$

$$\therefore\ m_A = 265.6\text{ kg}$$

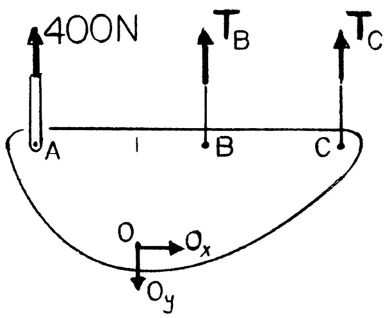
or $2.32\text{ kg} \le m_A \le 266\text{ kg}$ ◀



PROBLEM 4.10

A control rod is attached to a crank at A and cords are attached at B and C. For the given force in the rod, determine the range of values of the tension in the cord at C knowing that the cords must remain taut and that the maximum allowed tension in a cord is 180 N.

SOLUTION



f.b.d. of crank

For $\quad (T_C)_{max}, \qquad T_B = 0$

$$+\circlearrowleft \Sigma M_O = 0: \quad (T_C)_{max}(0.120 \text{ m}) - (400 \text{ N})(0.060 \text{ m}) = 0$$

$$(T_C)_{max} = 200 \text{ N} > T_{max} = 180 \text{ N}$$

$$\therefore \ (T_C)_{max} = 180.0 \text{ N}$$

For $\quad (T_C)_{min}, \ T_B = T_{max} = 180 \text{ N}$

$$+\circlearrowleft \Sigma M_O = 0: \quad (T_C)_{min}(0.120 \text{ m}) + (180 \text{ N})(0.040 \text{ m})$$

$$-(400 \text{ N})(0.060 \text{ m}) = 0$$

$$\therefore \ (T_C)_{min} = 140.0 \text{ N}$$

Therefore, $\quad 140.0 \text{ N} \le T_C \le 180.0 \text{ N}$ ◀