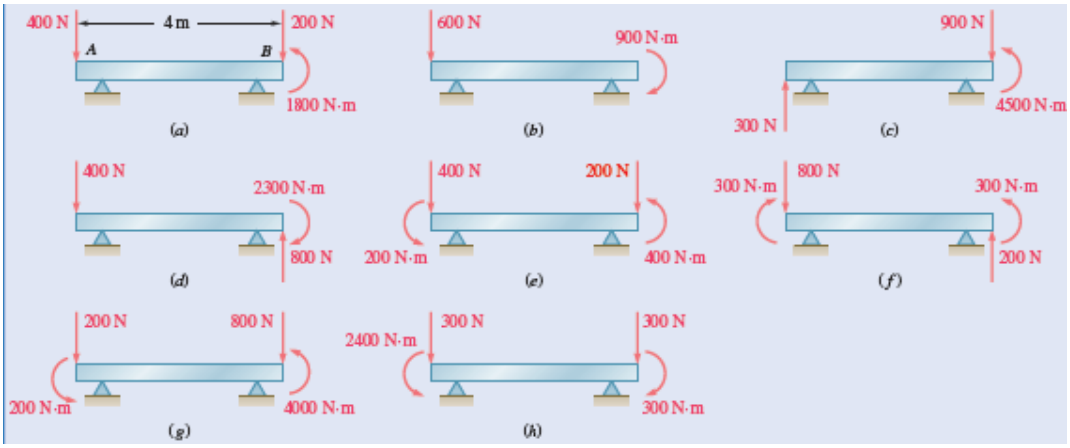
Solution 3.101

PROBLEM STATEMENT

A 4-m-long beam is subjected to a variety of loadings. (*a*) Replace each loading with an equivalent force-couple system at end *A* of the beam. (*b*) Which of the loadings are equivalent?



(*a*) (*a*) We have ΣF_y: $-400\text{ N} - 200\text{ N} = R_a$

or $\mathbf{R}_a = 600\text{ N}\downarrow$ ◀

and ΣM_A: $1800\text{ N}\cdot\text{m} - (200\text{ N})(4\text{ m}) = M_a$

or $\mathbf{M}_a = 1000\text{ N}\cdot\text{m}\circlearrowleft$ ◀

(*b*) We have ΣF_y: $-600\text{ N} = R_b$

or $\mathbf{R}_b = 600\text{ N}\downarrow$ ◀

and ΣM_A: $-900\text{ N}\cdot\text{m} = M_b$

or $\mathbf{M}_b = 900\text{ N}\cdot\text{m}\circlearrowright$ ◀

(*c*) We have ΣF_y: $300\text{ N} - 900\text{ N} = R_c$

or $\mathbf{R}_c = 600\text{ N}\downarrow$ ◀

and ΣM_A: $4500\text{ N}\cdot\text{m} - (900\text{ N})(4\text{ m}) = M_c$

or $\mathbf{M}_c = 900\text{ N}\cdot\text{m}\circlearrowleft$ ◀

Solution continued on next page…

(*d*) We have $\Sigma F_y: \quad -400\ \text{N} + 800\ \text{N} = R_d$

or $\mathbf{R}_d = 400\ \text{N} \uparrow$ ◀

and $\Sigma M_A: \quad (800\ \text{N})(4\ \text{m}) - 2300\ \text{N}\cdot\text{m} = M_d$

or $\mathbf{M}_d = 900\ \text{N}\cdot\text{m}$ ↻ ◀

(*e*) We have $\Sigma F_y: \quad -400\ \text{N} - 200\ \text{N} = R_e$

or $\mathbf{R}_e = 600\ \text{N} \downarrow$ ◀

and $\Sigma M_A: \quad 200\ \text{N}\cdot\text{m} + 400\ \text{N}\cdot\text{m} - (200\ \text{N})(4\ \text{m}) = M_e$

or $\mathbf{M}_e = 200\ \text{N}\cdot\text{m}$ ↺ ◀

(*f*) We have $\Sigma F_y: \quad -800\ \text{N} + 200\ \text{N} = R_f$

or $\mathbf{R}_f = 600\ \text{N} \downarrow$ ◀

and $\Sigma M_A: \quad -300\ \text{N}\cdot\text{m} + 300\ \text{N}\cdot\text{m} + (200\ \text{N})(4\ \text{m}) = M_f$

or $\mathbf{M}_f = 800\ \text{N}\cdot\text{m}$ ↻ ◀

(*g*) We have $\Sigma F_y: \quad -200\ \text{N} - 800\ \text{N} = R_g$

or $\mathbf{R}_g = 1000\ \text{N} \downarrow$ ◀

and $\Sigma M_A: \quad 200\ \text{N}\cdot\text{m} + 4000\ \text{N}\cdot\text{m} - (800\ \text{N})(4\ \text{m}) = M_g$

or $\mathbf{M}_g = 1000\ \text{N}\cdot\text{m}$ ↻ ◀

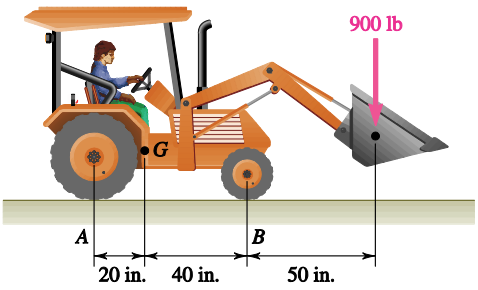
(*h*) We have $\Sigma F_y: \quad -300\ \text{N} - 300\ \text{N} = R_h$

or $\mathbf{R}_h = 600\ \text{N} \downarrow$ ◀

and $\Sigma M_A: \quad 2400\ \text{N}\cdot\text{m} - 300\ \text{N}\cdot\text{m} - (300\ \text{N})(4\ \text{m}) = M_h$

or $\mathbf{M}_h = 900\ \text{N}\cdot\text{m}$ ↻ ◀

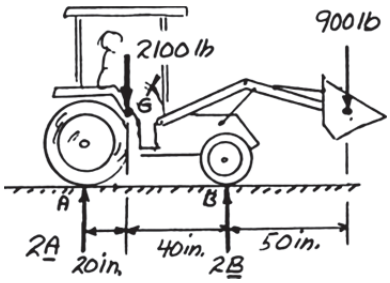
(*b*) Therefore, loadings (*c*) and (*h*) are equivalent. ◀



PROBLEM 4.3

A 2100-lb tractor is used to lift 900 lb of gravel. Determine the reaction at each of the two (*a*) rear wheels *A*, (*b*) front wheels *B*.

SOLUTION



(*a*) Rear wheels $+\circlearrowright \Sigma M_B = 0: \quad +(2100\text{ lb})(40\text{ in.}) - (900\text{ lb})(50\text{ in.}) + 2A(60\text{ in.}) = 0$

$$A = +325\text{ lb} \qquad \mathbf{A} = 325\text{ lb} \uparrow$$

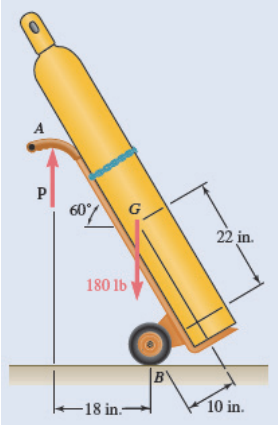
(*b*) Front wheels $+\circlearrowright \Sigma M_A: \quad -(2100\text{ lb})(20\text{ in.}) - (900\text{ lb})(110\text{ in.}) - 2B(60\text{ in.}) = 0$

$$B = +1175\text{ lb} \qquad \mathbf{B} = 1175\text{ lb} \uparrow$$

Check: $+\uparrow \Sigma F_y = 0: \quad 2A + 2B - 2100\text{ lb} - 900\text{ lb} = 0$

$$2(325\text{ lb}) + 2(1175\text{ lb}) - 2100\text{ lb} - 900 = 0$$

$$0 = 0 \quad \text{(Checks)}$$



PROBLEM 4.7

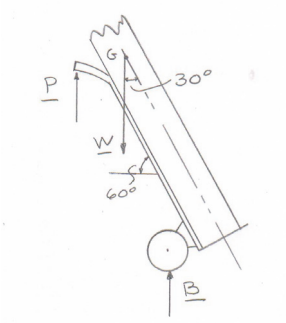
A hand truck is used to move a compressed-air cylinder. Knowing that the combined weight of the truck and cylinder is 180 lb, determine (*a*) the vertical force **P** that should be applied to the handle to maintain the cylinder in the position shown, (*b*) the corresponding reaction at each of the two wheels.

SOLUTION

(*a*) Let *C* be point of intersection of **W** with the ground.

Horizontal distance from *B* to *C* is:

Free-Body Diagram:



$$d = (22 \text{ in.})\sin 30^\circ - (10 \text{ in.})\cos 30^\circ$$
$$d = 2.3397 \text{ in.}$$

From free-body diagram of hand truck,

$$+\circlearrowleft \Sigma M_B = 0: \quad W(d) - P(18 \text{ in.}) = 0$$
$$(180 \text{ lb})(2.3397 \text{ in.}) - P(18 \text{ in.}) = 0$$
$$P = 23.397 \text{ lb}$$

$$\mathbf{P} = 23.4 \text{ lb} \uparrow \blacktriangleleft$$

(*b*)
$$+\uparrow \Sigma F_y = 0: \quad 2B + 23.397 \text{ lb} - 180 \text{ lb} = 0$$

or $\mathbf{B} = 78.3 \text{ lb} \uparrow$