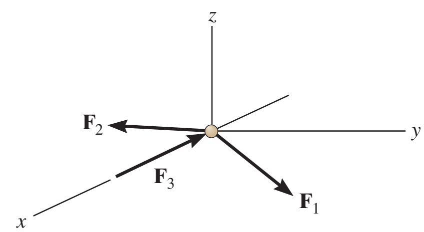
13–1.

The 6-lb particle is subjected to the action of its weight and forces $\mathbf{F}_1 = \{2\mathbf{i} + 6\mathbf{j} - 2t\mathbf{k}\}$ lb, $\mathbf{F}_2 = \{t^2\mathbf{i} - 4t\mathbf{j} - 1\mathbf{k}\}$ lb, and $\mathbf{F}_3 = \{-2t\mathbf{i}\}$ lb, where t is in seconds. Determine the distance the ball is from the origin 2 s after being released from rest.



SOLUTION

$$\Sigma \mathbf{F} = m\mathbf{a}; \quad (2\mathbf{i} + 6\mathbf{j} - 2t\mathbf{k}) + (t^2\mathbf{i} - 4t\mathbf{j} - 1\mathbf{k}) - 2t\mathbf{i} - 6\mathbf{k} = \left(\frac{6}{32.2}\right)(\mathbf{a}_x\mathbf{i} + a_y\mathbf{j} + a_z\mathbf{k})$$

Equating components:

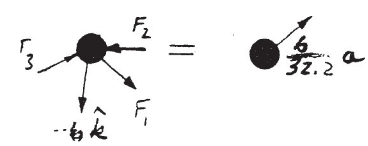
$$\left(\frac{6}{32.2}\right)a_x = t^2 - 2t + 2 \quad \left(\frac{6}{32.2}\right)a_y = -4t + 6 \quad \left(\frac{6}{32.2}\right)a_z = -2t - 7$$

Since $dv = a\,dt$, integrating from $\nu = 0, t = 0$, yields

$$\left(\frac{6}{32.2}\right)v_x = \frac{t^3}{3} - t^2 + 2t \quad \left(\frac{6}{32.2}\right)v_y = -2t^2 + 6t \quad \left(\frac{6}{32.2}\right)v_z = -t^2 - 7t$$

Since $ds = v\,dt$, integrating from $s = 0, t = 0$ yields

$$\left(\frac{6}{32.2}\right)s_x = \frac{t^4}{12} - \frac{t^3}{3} + t^2 \quad \left(\frac{6}{32.2}\right)s_y = -\frac{2t^3}{3} + 3t^2 \quad \left(\frac{6}{32.2}\right)s_z = -\frac{t^3}{3} - \frac{7t^2}{2}$$



When $t = 2$ s then, $s_x = 14.31$ ft, $s_y = 35.78$ ft $s_z = -89.44$ ft

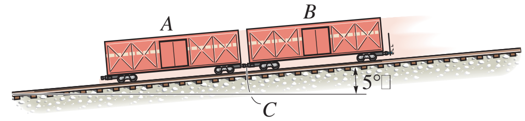
Thus,

$$s = \sqrt{(14.31)^2 + (35.78)^2 + (-89.44)^2} = 97.4 \text{ ft}$$ **Ans.**

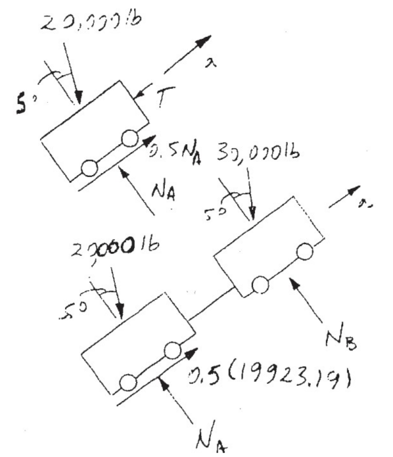
Ans:
$s = 97.4$ ft

13–2.

The two boxcars A and B have a weight of 20 000 lb and 30 000 lb, respectively. If they are freely coasting down the incline when the brakes are applied to all the wheels of car A, determine the force in the coupling C between the two cars. The coefficient of kinetic friction between the wheels of A and the tracks is $\mu_k = 0.5$. The wheels of car B are free to roll. Neglect their mass in the calculation. *Suggestion:* Solve the problem by representing single resultant normal forces acting on A and B, respectively.



SOLUTION



Car A:

$+\nwarrow \Sigma F_y = 0;\qquad N_A - 20\,000 \cos 5^\circ = 0 \qquad N_A = 19\,923.89 \text{ lb}$

$$+\nearrow \Sigma F_x = ma_x;\qquad 0.5(19\,923.89) - T - 20\,000 \sin 5^\circ = \left(\frac{20\,000}{32.2}\right)a \qquad (1)$$

Both cars:

$$+\nearrow \Sigma F_x = ma_x;\qquad 0.5(19\,923.89) - 50\,000 \sin 5^\circ = \left(\frac{50\,000}{32.2}\right)a$$

Solving,

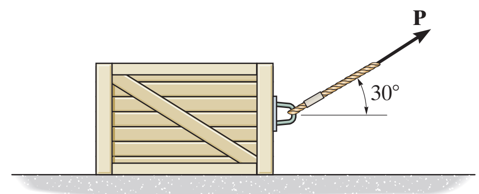
$a = 3.61 \text{ ft/s}^2$

$T = 5.98 \text{ kip}$ **Ans.**

Ans:
$T = 5.98$ kip

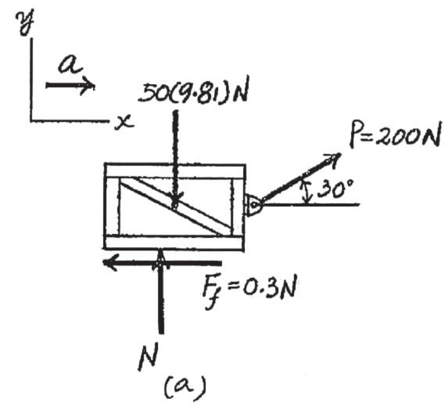
13–3.

If the coefficient of kinetic friction between the 50-kg crate and the ground is $\mu_k = 0.3$, determine the distance the crate travels and its velocity when $t = 3$ s. The crate starts from rest, and $P = 200$ N.



SOLUTION

Free-Body Diagram: The kinetic friction $F_f = \mu_k N$ is directed to the left to oppose the motion of the crate which is to the right, Fig. *a*.



Equations of Motion: Here, $a_y = 0$. Thus,

$$+\uparrow \Sigma F_y = 0; \quad N - 50(9.81) + 200 \sin 30° = 0$$

$$N = 390.5 \text{ N}$$

$$\xrightarrow{+} \Sigma F_x = ma_x; \quad 200 \cos 30° - 0.3(390.5) = 50a$$

$$a = 1.121 \text{ m/s}^2$$

Kinematics: Since the acceleration **a** of the crate is constant,

$$(\xrightarrow{+}) \quad v = v_0 + a_c t$$

$$v = 0 + 1.121(3) = 3.36 \text{ m/s} \qquad \textbf{Ans.}$$

and

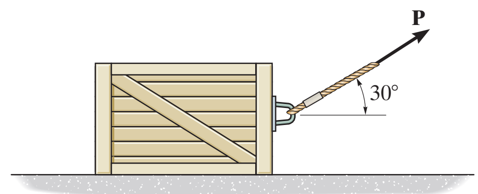
$$(\xrightarrow{+}) \quad s = s_0 + v_0 t + \frac{1}{2} a_c t^2$$

$$s = 0 + 0 + \frac{1}{2}(1.121)\left(3^2\right) = 5.04 \text{ m} \qquad \textbf{Ans.}$$

Ans:
$v = 3.36$ m/s
$s = 5.04$ m

***13–4.**

If the 50-kg crate starts from rest and achieves a velocity of $v = 4\text{ m/s}$ when it travels a distance of 5 m to the right, determine the magnitude of force **P** acting on the crate. The coefficient of kinetic friction between the crate and the ground is $\mu_k = 0.3$.



SOLUTION

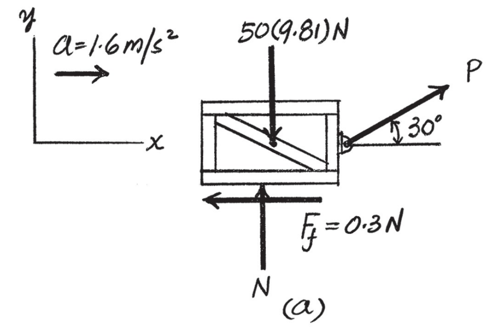
Kinematics: The acceleration **a** of the crate will be determined first since its motion is known.

$$(\xrightarrow{+}) \qquad v^2 = v_0^{\,2} + 2a_c(s - s_0)$$

$$4^2 = 0^2 + 2a(5 - 0)$$

$$a = 1.60\text{ m/s}^2 \rightarrow$$

Free-Body Diagram: Here, the kinetic friction $F_f = \mu_k N = 0.3N$ is required to be directed to the left to oppose the motion of the crate which is to the right, Fig. *a*.



Equations of Motion:

$$+\uparrow \Sigma F_y = ma_y; \qquad N + P\sin 30^\circ - 50(9.81) = 50(0)$$

$$N = 490.5 - 0.5P$$

Using the results of **N** and **a**,

$$\xrightarrow{+} \Sigma F_x = ma_x; \qquad P\cos 30^\circ - 0.3(490.5 - 0.5P) = 50(1.60)$$

$$P = 224\text{ N}$$ **Ans.**

Ans:
$P = 224\text{ N}$