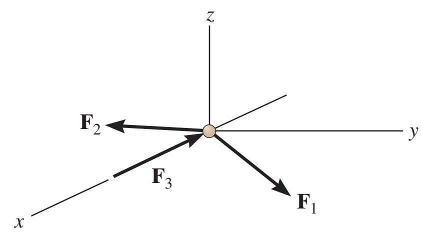
13–1.

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:

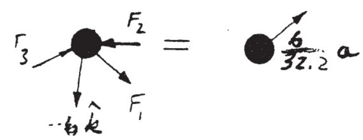
$$\left(\frac{6}{32.2}\right)a_x = t^2 - 2t + 2 \qquad \left(\frac{6}{32.2}\right)a_y = -4t + 6 \qquad \left(\frac{6}{32.2}\right)a_z = -2t - 7$$

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

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

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

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



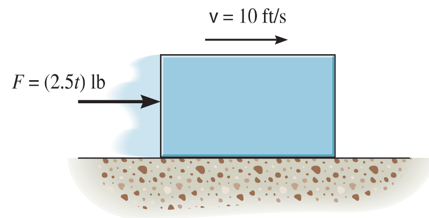
When $t = 2$ s then, $\quad s_x = 14.31$ ft, $\qquad s_y = 35.78$ ft $\qquad s_z = -89.44$ ft

Thus,

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

13–2.

The 10-lb block has an initial velocity of 10 ft/s on the smooth plane. If a force $F = (2.5t)$ lb, where t is in seconds, acts on the block for 3 s, determine the final velocity of the block and the distance the block travels during this time.



SOLUTION

$$\xrightarrow{+} \Sigma F_x = ma_x; \qquad 2.5t = \left(\frac{10}{32.2}\right)a$$

$$a = 8.05t$$

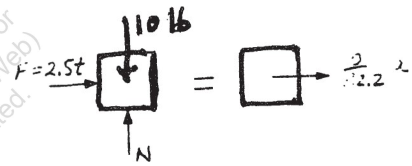
$$dv = a\,dt$$

$$\int_{10}^{v} dv = \int_0^t 8.05t\,dt$$

$$v = 4.025t^2 + 10$$

When $t = 3$ s,

$$v = 46.2 \text{ ft/s} \qquad \textbf{Ans.}$$



$$ds = v\,dt$$

$$\int_0^s ds = \int_0^t (4.025t^2 + 10)\,dt$$

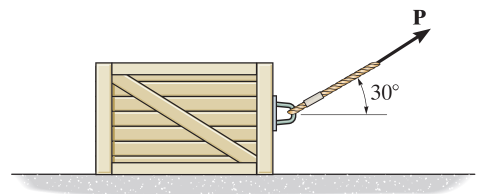
$$s = 1.3417t^3 + 10t$$

When $t = 3$ s,

$$s = 66.2 \text{ ft} \qquad \textbf{Ans.}$$

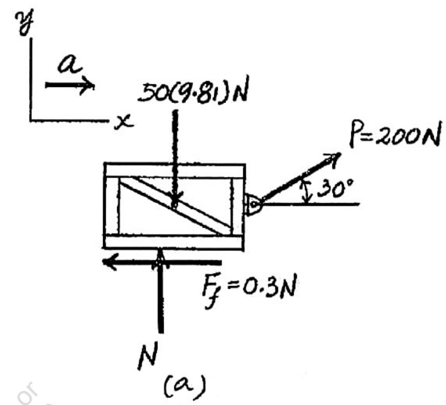
13–3.

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,

$$+\uparrow \Sigma F_y = 0; \qquad N - 50(9.81) + 200 \sin 30^\circ = 0$$

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

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

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

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

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

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

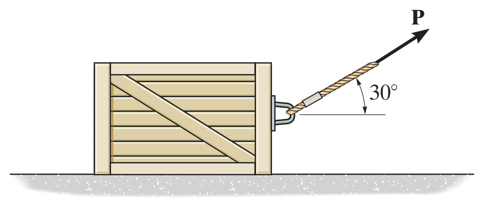
and

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

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

***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 $\mu_k = 0.3$.



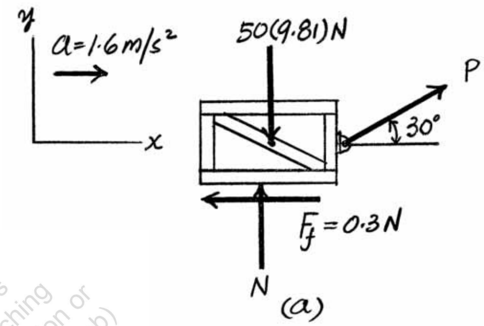
SOLUTION

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

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

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

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



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:

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

$$N = 490.5 - 0.5P$$

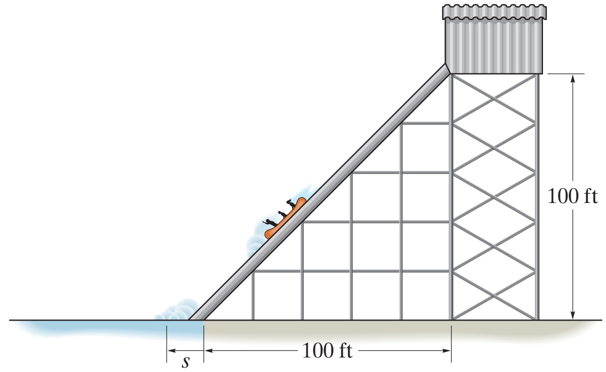
Using the results of **N** and **a**,

$\overset{+}{\rightarrow}\Sigma F_x = ma_x;\qquad P\cos 30° - 0.3(490.5 - 0.5P) = 50(1.60)$

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

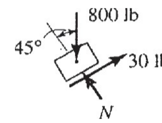
13–5.

The water-park ride consists of an 800-lb sled which slides from rest down the incline and then into the pool. If the frictional resistance on the incline is $F_r = 30$ lb, and in the pool for a short distance $F_r = 80$ lb, determine how fast the sled is traveling when $s = 5$ ft.



SOLUTION

$$+\swarrow \sum F_x = ma_x; \qquad 800 \sin 45^\circ - 30 = \frac{800}{32.2}a$$



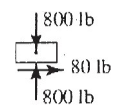
$$a = 21.561 \text{ ft/s}^2$$

$$v_1^2 = v_0^2 + 2a_c(s - s_0)$$

$$v_1^2 = 0 + 2(21.561)(100\sqrt{2} - 0))$$

$$v_1 = \ = 78.093 \text{ ft/s}$$

$$\overset{+}{\leftarrow} \sum F_x = ma_x; \qquad -80 = \frac{800}{32.2}a$$



$$a = -3.22 \text{ ft/s}^2$$

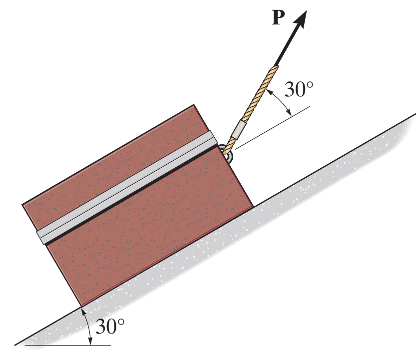
$$v_2^2 = v_1^2 + 2a_c(s_2 - s_1)$$

$$v_2^2 = (78.093)^2 + 2(-3.22)(5 - 0)$$

$$v_2 = 77.9 \text{ ft/s}$$ **Ans.**

13–6.

If $P = 400$ N and the coefficient of kinetic friction between the 50-kg crate and the inclined plane is $\mu_k = 0.25$, determine the velocity of the crate after it travels 6 m up the plane. The crate starts from rest.



SOLUTION

Free-Body Diagram: Here, the kinetic friction $F_f = \mu_k N = 0.25N$ is required to be directed down the plane to oppose the motion of the crate which is assumed to be directed up the plane. The acceleration **a** of the crate is also assumed to be directed up the plane, Fig. *a*.

Equations of Motion: Here, $a_{y'} = 0$. Thus,

$$\Sigma F_{y'} = ma_{y'}; \qquad N + 400 \sin 30° - 50(9.81) \cos 30° = 50(0)$$

$$N = 224.79 \text{ N}$$

Using the result of **N**,

$$\Sigma F_{x'} = ma_{y'}; \qquad 400 \cos 30° - 50(9.81) \sin 30° - 0.25(224.79) = 50a$$

$$a = 0.8993 \text{ m/s}^2$$

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

$$v^2 = v_0{}^2 + 2a_c(s - s_0)$$

$$v^2 = 0 + 2(0.8993)(6 - 0)$$

$$v = 3.29 \text{ m/s} \qquad \textbf{Ans.}$$