#### 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.



6 <u>6</u> a

## 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 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

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

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.

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### 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.



+ 2.2 ×

## SOLUTION

When t = 3 s,

$$v = 46.2 \text{ m/s}$$
  

$$ds = v \, dt$$
  

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

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

10001

When 
$$t = 3 s$$

$$s = 66.2 \, \text{ft}$$

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### 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,  $a_v = 0$ . Thus,

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

N = 390.5 N

$$\pm \Sigma F_x = ma_x$$
; 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,

$$( \stackrel{+}{\to} )$$
  $v = v_0 + a_c t$   
 $v = 0 + 1.121(3) = 3.36 \text{ m/s}$ 

and

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

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

 $\begin{array}{c} a \\ \hline 50(9.81)N \\ \hline F_{g}=0.3N \\ N \\ (a) \end{array}$ 

Successful and the state of the

Ans.

#### \*13-4.

If the 50-kg crate starts from rest and achieves a velocity of v = 4 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 ie known

(
$$\pm$$
)  
 $v^2 = v_0^2 + 2a_c(s - s_0)$   
 $4^2 = 0^2 + 2a(5 - 0)$   
 $a = 1.60 \text{ m/s}^2 \rightarrow$ 

*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:**

$$+\uparrow \Sigma F_y = ma_y;$$
  $N + P \sin 30^\circ - 50(9.81) = 50(0)$   
 $N = 490.5 - 0.5P$ 

Using the results of N and a,

and the second the second seco  $P\cos 30^\circ - 0.3(490.5 - 0.5P) = 50(1.60)$  $\Rightarrow \Sigma F_x = ma_x;$ inclum and Ans. P = 224 N



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#### 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

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

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

$$v_{1}^{2} = v_{0}^{2} + 2a_{c}(s - s_{0})$$

$$v_{1}^{2} = 0 + 2(21.561)(100\sqrt{2 - 0}))$$

$$v_{1} = 78.093 \text{ ft/s}$$

$$\not\equiv \sum F_{x} = ma_{x}; \qquad -80 = \frac{800}{32.2}a$$

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

$$v_{2}^{2} = v_{1}^{2} + 2a_{c}(s_{2} - s_{1})$$

$$v_{2}^{2} = (78.093)^{2} + 2(-3.22)(5 - 0)$$

$$v_{2} = 77.9 \text{ ft/s}$$
Ans.

100 ft

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## 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.

 $400\cos 30^{\circ} - 50(9.81)\sin 30^{\circ} - 0.25(224.79) = 50a$ 

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

 $N + 400 \sin 30^{\circ} - 50(9.81) \cos 30^{\circ} = 50(0)$  $\Sigma F_{\nu'} = ma_{\nu'};$ N = 224.79 N

Using the result of N,

$$\Sigma F_{x'} = ma_{y'};$$

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

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

$$v^{2} = v_{0}^{2} + 2a_{c}(s - s_{0})$$
  
 $v^{2} = 0 + 2(0.8993)(6 - 0)$   
 $v = 3.29 \text{ m/s}$ 

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