$$\int_{10}^{v} \frac{dv}{v} = -\frac{1}{2}\int_{0}^{t} dt,$$

$$\ln v \Big|_{10}^{v} = -\frac{1}{2}t \Big|_{0}^{t},$$

$$\ln\left(\frac{v}{10}\right) = -\frac{1}{2}t,$$

$$v = (10e^{-t/2})\ \text{m/s}. \qquad \text{ANS.}$$

■

Problems

13.30 A bead moves along a taut wire as shown in Figure P13.30 such that its acceleration in m/s^2 is given as a function of time in s by $a = 6t - 14$. Initially, when $t = 0$ s, the particle is 8 m to the left of the origin and moving 14 m/s to the right. Determine (a) the velocity as a function of time, (b) the position as a function of time, and (c) the displacement during the time interval from $t =$ 4 s to $t = 8$ s.

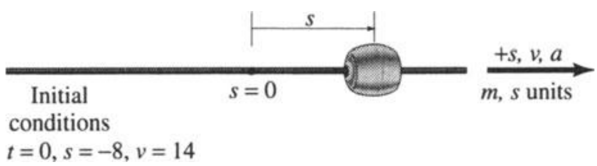

FIGURE P13.30.

13.31 The velocity function $v = t^2 - 25t + 150$ is specified for the rectilinear motion of a particle where v is expressed in ft/s and t is expressed in s. The particle is at the origin when the clock is started. Determine (a) the acceleration as a function of time, (b) the position as a function of time, (c) the times for which the velocity equals zero, (d) the displacement from $t = 0$ to $t = 5$ s, and (e) the distance traveled during the time interval from $t = 0$ to $t = 8$ s.

13.32 A vehicle starts from rest at the origin at $t = 0$ and moves such that $a = 10 - 5t$ where a is measured in m/s^2 and t in s. Find the acceleration, velocity, and position of the particle when $t = 2$ s.

13.33 The straight line motion of a small block shown in Figure P13.33 is such that $a = Ak^2 \sinh kt$ where a is expressed in m/s^2 and t in s. The block is at the origin when the clock is started. When $t = 0$, $v = 10$ m/s and $t = 1$ s, $v = 20$ m/s. Determine (a) the velocity as a function of time and (b) the position as a function of time.

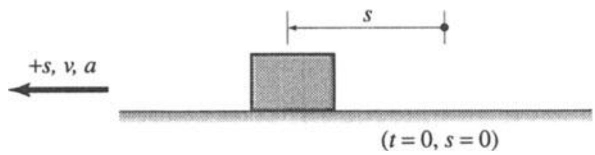

FIGURE P13.33.

13.34 Rectilinear particle motion occurs such that the acceleration is given by $a = A \sinh kt$ where a is expressed in ft/s^2 and t in s. When $t = 0$, $v = 100$ ft/s and when $t = 5$ s, $v = 200$ ft/s. The ratio of A to k is 50, and $s = 0$ at $t = 0$. Determine (a) the numerical values for A and k, (b) the position, velocity, and acceleration of the particle when $t = 2$ s and (c) the units of A and k.

13.35 A particle starts from rest at the origin when $t = 0$ and moves according to $a = t^3 - 6t^2 + 11t - 6$ where a is expressed in m/s^2 and t in s. Find (a) the velocity as a function of time, (b) the position as a function of time, and (c) sketch the motion curves (i.e., a-t, v-t and s-t curves) for the time interval from $t = 0$ to $t = 4$ s.

13.36 The acceleration of a small block, which oscillates along the inclined plane shown in Figure P13.36, is given by $a = -\pi^2 A \sin \pi t$ where a is in inch/s^2 and t is in s. When $t = 0$, then, $v = \pi A$ in./s and $s = 0$. The constant A is the amplitude of the vibration. Determine (a) the velocity as a function of time, (b) the position as a function of time, and (c) sketch the motion curves (i.e., a-t, v-t and s-t curves) for the time interval from $t = 0$ to $t = 2$ s.

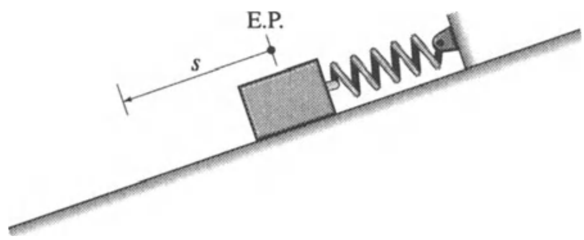

FIGURE P13.36.

13.37 In Figure P13.37 the vibratory motion of a small body along a vertical straight line is defined by $a = -A\pi^2 \cos \pi t$ where a is in m/s^2 and t is in s. When $t = 0$, $s = 1$ m, and $v = 0$, determine (a) the velocity as a function of time, (b) the position as a function of time, and (c) let $A = 1.00$, and sketch the motion curves (i.e., a-t, v-t and s-t curves) for the time interval from $t = 0$ to $t = 2$ s.

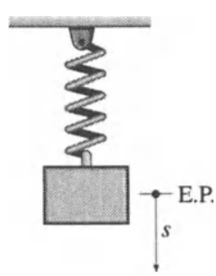

FIGURE P13.37.

13.38 A particle is at rest at the origin when $t = 0$. It moves such that $a = mt + b$ where m and b are constants and a is measured in inch/s^2 and t in s. Find (a) the velocity as a function of time, (b) the position as a function of time, and (c) what special case arises for $m = 0$?

13.39 The motion of a particle along a straight line is defined by $a = A + B \sin \pi t$ where A and B are constants. The acceleration is measured in m/s^2 and the time in s. When $t = 0$, $s = 0$ and $v = -1/\pi$, determine (a) the velocity as a function of time and specialize it for $A = 2$ and $B = 1$, and (b) the position as a function of time and specialize it for $A = 2$ and $B = 1$.

13.40 The velocity function $v = At^2 + Bt + C$ is specified for the rectilinear motion of a particle where v is expressed in m/s and t in s. When $t = 0$, $s = 0$, $v = 1$ m/s; $t = 0$, $a = 2$ m/s^2 and at $t = 1$, $v = 6$ m/s. Determine (a) the constants A, B, C. Be sure to state their units, (b) the acceleration-time function, and (c) the position-time function.

13.41 Refer to the acceleration-time plot shown in Figure P13.41 for a vehicle which moves along a straight-line path. It has an initial velocity of 10 ft/s. Plot the velocity-time curve for this vehicle for the 10 s interval shown. What is the velocity of the vehicle when $t = 3$ s and when $t = 10$ s?

13.42 Refer to the velocity-time plot shown in Figure P13.42 for a vehicle which moves

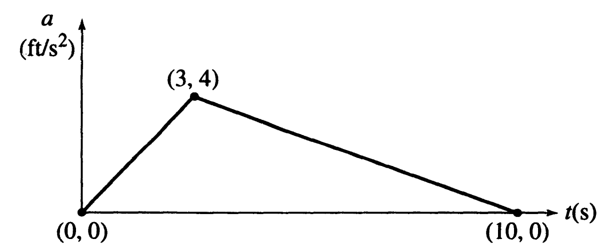

FIGURE P13.41.

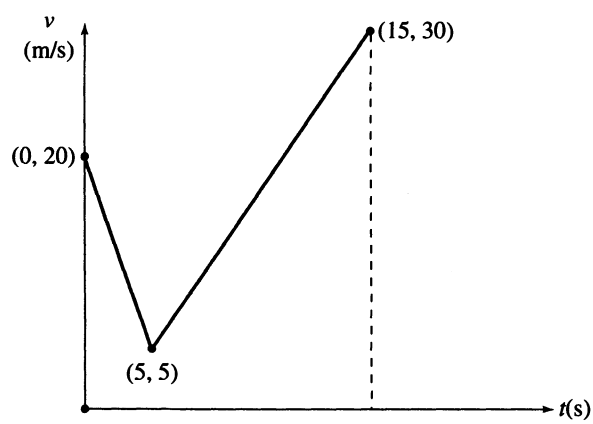

FIGURE P13.42.

13.73 The velocity of a vehicle is reduced from 50 ft/s to 30 ft/s as it moves 100 ft along a straight-line path. Determine the constant deceleration of the vehicle.

13.74 The velocity of a vehicle is increased from 30 m/s to 40 m/s as it moves 45 m along a straight-line path. Determine the constant acceleration of the vehicle.

13.75 A high speed train is traveling along a straight, level roadbed at a speed of 240 km/hr as shown in Figure P13.75. Determine its stopping distance if the deceleration is constant and equal to 7.0 m/s^2. How much time elapsed during which the brakes were applied to stop this train?

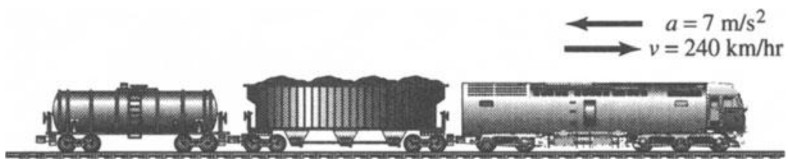

FIGURE P13.75.

13.76 A supersonic jet aircraft, shown in Figure P13.76, must reduce its velocity from 1000 mph to 600 mph in 5 seconds. Determine the constant deceleration required. Express your answer in ft/s^2. What distance did this jet plane travel in straight, level flight during this deceleration phase?

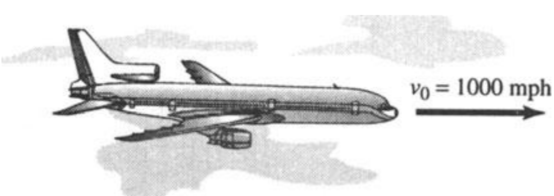

FIGURE P13.76.

13.77 An automobile's velocity is increased from 45 ft/s to 90 ft/s as it moves 120 ft over a straight, level highway. Determine its constant acceleration. How long did this accelerating phase last?

13.78 A toy car moves with constant acceleration of 2 m/s^2 along a straight-line path. The positive sense is directed to the right for this motion. Initial conditions are $t = 0$, $s = -10$ m; $t = 0$, $v = -4$ m/s. Express s and v as functions of time. Determine the position and velocity of the toy car when $t = 2$ s.

13.79 A racing car is moving along a straight stretch of race track shown in Figure P13.79. Its velocity is increased from 120 mph to 125 mph as it moves 60 ft. Determine its constant acceleration.

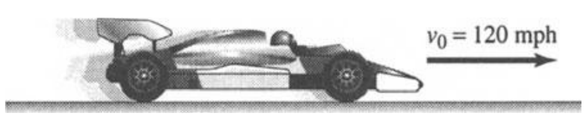

FIGURE P13.79.

13.80 A skater moving along a straight line on the surface of a frozen lake is decelerated at 0.1 m/s^2. If she comes to rest after moving 50 m, what was her initial velocity? How long did she move across the ice?

sured in rad/s, and t is the time measured in s. Initial conditions of the motion are $t = 0$, $x = 0$, $y = a$, $\dot{x} = a\omega$, and $\dot{y} = 0$. Determine the scalar components of velocity, the x and y coordinates of the particle at any time t, and the equation of the path.

13.99 A particle moves on a path in the x-y plane such that $\ddot{x} = -a\omega^2 \sin \omega t$ and $\ddot{y} = -a\omega^2 \cos \omega t$. Initial conditions of the motion are $t = 0$, $x = c$, $y = d + a$, $\dot{x} = a\omega$, and $\dot{y} = 0$. Constants a, c, and d are measured in m, the constant ω is measured in rad/s, and the time t is given in s. Determine the velocity vector and the position vector at any time t, and find the equation of the path.

13.100 Planar motion of a particle takes place such that the scalar acceleration components are given by $\ddot{x} = 2$ and $\ddot{y} = 12t^2$ where the units are in. and s. The initial conditions are $t = 0$, $x = c$, $y = d$, $\dot{x} = 0$, $\dot{y} = 0$. Constants c and d are measured in inches. Determine the velocity and position vectors as functions of time. Find the equation of the path by eliminating the parameter t. Sketch the path and the position and velocity vectors.

13.101 Curvilinear motion takes place in the x-y plane such that the scalar acceleration components are given by $\ddot{x} = 12t^2$ and $\ddot{y} = 56t^6$. Units are m and s. Initial conditions of the motion are $t = 0$, $x = c$, $y = d$, $\dot{x} = 0$, $\dot{y} = 0$. Constants c and d are expressed in m. Determine the velocity and position vectors of the particle when $t = 1$ s if $c = -0.5$ m and $d = 2$ m. Sketch the path and the required vectors.

13.102 The position vector from a fixed origin to a particle moving along a curvilinear path is given by $\mathbf{r} = (c + t^2)\mathbf{i} + (d + t^6)\mathbf{j}$. Units are ft and s, and the constants c and d are given in ft. Determine (a) the path and its equation, (b) the velocity and acceleration vectors, and (c), for $t = 1$ s, $c = 1$ ft, $d = -2$ ft, sketch the path, and show the above vectors on your sketch.

13.103 A particle moving along a curvilinear path in the x-y plane is positioned by the vector $\mathbf{r} = a \sin \omega t\mathbf{i} + b \cos \omega t\mathbf{j}$, where the constants a and b are given in m, the constant ω is given in rad/s, and time is given in s. Determine (a) the path and its equation, (b) the velocity vector, and (c) the acceleration vector.

13.104 Acceleration components for the motion of a particle in the x-y plane are given by $\ddot{x} = -a\omega^2 \sin \omega t$ and $\ddot{y} = -b\omega^2 \cos \omega t$. Initial conditions of the motion are $t = 0$, $x = 0$, $y = b$, $\dot{x} = a\omega$, $\dot{y} = 0$. Constants a and b are measured in ft., the constant ω is measured in rad/s, and time is measured in s. Determine the velocity vector and the position vector at any time t, and find the equation of the path. Sketch the path and the velocity and position vectors. Why is this a periodic motion?

13.105 The straight-line path of a toy train is given by $y = 6 + 4x$ where $x = 4t$. Units are in. and s. Find y as a function of t and the vectors $\mathbf{r}$, $\mathbf{v}$ and $\mathbf{a}$. Is the train accelerating?

13.106 The position of a cannon ball shown in Figure P13.106 may be determined

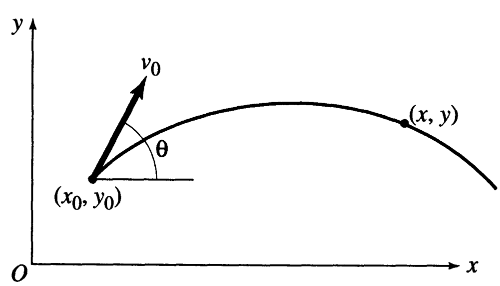

FIGURE P13.106.

from the equations $x = x_0 + (v_0 \sin\theta)t$ and $y = y_0 + (v_0 \cos\theta)t - \frac{1}{2}gt^2$, where (x_0, y_0) denotes the initial position of the projectile when it is fired at an angle θ to the horizontal and v_0 is its initial velocity. The ball's range and its altitude during its motion are such that the acceleration due to gravity g may be assumed constant. Atmospheric resistance is neglected. (a) Differentiate these equations for x and y with respect to time to write equations for the velocity components in the x and y directions. (b) Differentiate the velocity components equations to obtain the acceleration components in the x and y directions.

13.107 A baseball is hit as indicated in Figure P13.107. You are to decide which trajectory is the correct one. If trajectory 1 is correct, where does the ball hit the ground, assuming a fielder is unable to catch it? If trajectory 2 is correct, where will the ball hit the wall? If trajectory 3 is correct, by what distance will the ball clear the wall? The origin is selected at the point where the ball is hit. Break the motion into x and y components. The velocity in the x direction remains constant if we neglect air resistance. The constant acceleration in the y direction is $-g = -32.2$ ft/s^2.

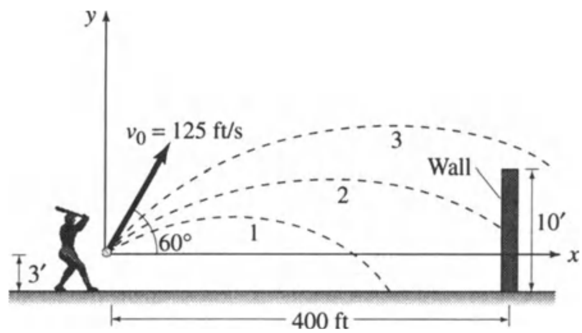

FIGURE P13.107.

13.108 A projectile is fired from the origin with an initial velocity of 400 ft/s at an angle of 30° to the horizontal. (a) Write the equation of its path, (b) Determine the range of this projectile, and (c) Find the maximum height above the horizontal reached by the projectile.

13.109 A projectile is fired from the point whose coordinates are $x_0 = 200$ ft, $y_0 = 400$ ft. It has an initial velocity of 500 ft/s and makes an initial angle of 40° with the positive x axis. (a) Express x and y as functions of time. (b) Determine the x coordinate on the path corresponding to $y = -100$ ft.

13.110 A projectile is launched from the origin with an initial velocity of 300 m/s at an angle of θ to the horizontal. It strikes a point 2000 m to the right of the origin on a horizontal plane. Determine the two possible values for θ, and sketch the trajectories.

13.111 A person is shot from a cannon at a circus as shown in Figure P13.111. For trajectory 1, find θ_1, and, for trajectory 2, find θ_2. Assume $v_1 = v_2 = 200$ ft/s,