Solution Manual for Engineering Mechanics Dynamics 13th Edition by Hibbeler ISBN 0132911272 9870132911276

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SOLUTION MANUAL CONTENTS

12–1.

A baseball is thrown downward from a 50-ft tower with an initial speed of 18 ft>s. Determine the speed at which it hits the ground and the time of travel.

SOLUTION

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

$$v_2^2 = (18)^2 + 2(32.2)(50 - 0)$$

$$v_2 = 59.532 = 59.5 \text{ ft/s}$$ **Ans.**

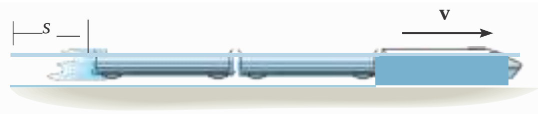
$$v_2 = v_1 + a_c t$$

$$59.532 = 18 + 32.2(t)$$

$$t = 1.29 \text{ s}$$ **Ans.**

12–2.

When a train is traveling along a straight track at 2 m/s, it begins to accelerate at $a = (60\,v^{-4})\ \text{m/s}^2$, where v is in m/s. Determine its velocity v and the position 3 s after the acceleration.



SOLUTION

$$a = \frac{dv}{dt}$$

$$dt = \frac{dv}{a}$$

$$\int_0^3 dt = \int_2^v \frac{dv}{60v^{-4}}$$

$$3 = \frac{1}{300}\left(v^5 - 32\right)$$

$$v = 3.925\ \text{m/s} = 3.93\ \text{m/s} \qquad \textbf{Ans.}$$

$$a\,ds = v\,dv$$

$$ds = \frac{v\,dv}{a} = \frac{1}{60} v^5\,dv$$

$$\int_0^s ds = \frac{1}{60}\int_2^{3.925} v^5\,dv$$

$$s = \frac{1}{60}\left(\frac{v^6}{6}\right)\Bigg|_2^{3.925}$$

$$= 9.98\ \text{m} \qquad \textbf{Ans.}$$

12–3.

From approximately what floor of a building must a car be dropped from an at-rest position so that it reaches a speed of 80.7 ft>s 155 mi>h2 when it hits the ground? Each floor is 12 ft higher than the one below it. (*Note:* You may want to remember this when traveling 55 mi>h.)

SOLUTION

$(+\downarrow)\qquad v^2 = v_0^2 + 2a_c(s - s_0)$

$$80.7^2 = 0 + 2(32.2)(s - 0)$$

$$s = 101.13 \text{ ft}$$

$$\text{\# of floors} = \frac{101.13}{12} = 8.43$$

The car must be dropped from the 9th floor. **Ans.**

***12–4.**

Traveling with an initial speed of 70 km>h, a car accelerates at 6000 km>h^2 along a straight road. How long will it take to reach a speed of 120 km>h? Also, through what distance does the car travel during this time?

SOLUTION

$v = v_1 + a_c t$

$120 = 70 + 6000(t)$

$t = 8.33(10^{-3})$ hr $= 30$ s **Ans.**

$v^2 = v_1^2 + 2a_c(s - s_1)$

$(120)^2 = 70^2 + 2(6000)(s - 0)$

$s = 0.792$ km $= 792$ m **Ans.**

12–5.

A bus starts from rest with a constant acceleration of 1 m>s^2. Determine the time required for it to attain a speed of 25 m>s and the distance traveled.

SOLUTION

Kinematics:

$v_0 = 0$, $v = 25$ m>s, $s_0 = 0$, and $a_c = 1$ m>s^2.

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

$25 = 0 + (1)t$

$t = 25$ s **Ans.**

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

$25^2 = 0 + 2(1)(s - 0)$

$s = 312.5$ m **Ans.**

12–6.

A stone A is dropped from rest down a well, and in 1 s another stone B is dropped from rest. Determine the distance between the stones another second later.

SOLUTION

$$+\text{T}\ s = s_1 + v_1 t + \frac{1}{2}a_c t^2$$

$$s_A = 0 + 0 + \frac{1}{2}(32.2)(2)^2$$

$$s_A = 64.4 \text{ ft}$$

$$s_A = 0 + 0 + \frac{1}{2}(32.2)(1)^2$$

$$s_B = 16.1 \text{ ft}$$

$$¢s = 64.4 - 16.1 = 48.3 \text{ ft}$$ **Ans.**

12–7.

A bicyclist starts from rest and after traveling along a straight path a distance of 20 m reaches a speed of 30 km/h. Determine his acceleration if it is *constant*. Also, how long does it take to reach the speed of 30 km/h?

SOLUTION

$v_2 = 30 \text{ km/h} = 8.33 \text{ m/s}$

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

$(8.33)^2 = 0 + 2 a_c (20 - 0)$

$a_c = 1.74 \text{ m/s}^2$ **Ans.**

$v_2 = v_1 + a_c t$

$8.33 = 0 + 1.74(t)$

$t = 4.80 \text{ s}$ **Ans.**

•12–8.

A particle moves along a straight line with an acceleration of $a = 5/(3s^{1/3} + s^{5/2})$ m/s^2, where s is in meters. Determine the particle's velocity when $s = 2$ m, if it starts from rest when $s = 1$ m. Use Simpson's rule to evaluate the integral.

SOLUTION

$$a = \frac{5}{\left(3s^{\frac{1}{3}} + s^{\frac{5}{2}}\right)}$$

$a\,ds = v\,dv$

$$\int_1^2 \frac{5\,ds}{\left(3s^{\frac{1}{3}} + s^{\frac{5}{2}}\right)} = \int_0^v v\,dv$$

$$0.8351 = \frac{1}{2}v^2$$

$v = 1.29$ m/s **Ans.**

12–9.

If it takes 3 s for a ball to strike the ground when it is released from rest, determine the height in meters of the building from which it was released. Also, what is the velocity of the ball when it strikes the ground?

SOLUTION

Kinematics:

$v_0 = 0$, $a_c = g = 9.81\ \text{m/s}^2$, $t = 3\ \text{s}$, and $s = h$.

$$(+\downarrow) \qquad v = v_0 + a_c t$$

$$= 0 + (9.81)(3)$$

$$= 29.4\ \text{m/s}$$

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

$$h = 0 + 0 + \frac{1}{2}(9.81)(3^2)$$

$$= 44.1\ \text{m}$$

Ans.

12–10.

The position of a particle along a straight line is given by $s = (1.5t^3 - 13.5t^2 + 22.5t)$ ft, where t is in seconds. Determine the position of the particle when $t = 6$ s and the total distance it travels during the 6-s time interval. *Hint:* Plot the path to determine the total distance traveled.

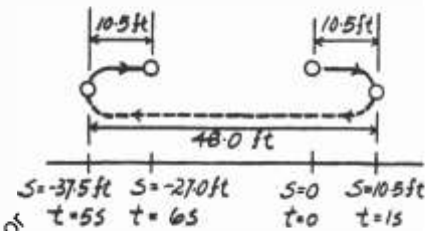
SOLUTION

Position: The position of the particle when $t = 6$ s is

$$s|_{t=6s} = 1.5(6^3) - 13.5(6^2) + 22.5(6) = -27.0 \text{ ft} \qquad \textbf{Ans.}$$

Total Distance Traveled: The velocity of the particle can be determined by applying Eq. 12–1.

$$v = \frac{ds}{dt} = 4.50t^2 - 27.0t + 22.5$$



The times when the particle stops are

$$4.50t^2 - 27.0t + 22.5 = 0$$

$$t = 1 \text{ s} \qquad \text{and} \qquad t = 5 \text{ s}$$

The position of the particle at $t = 0$ s, 1 s and 5 s are

$$s|_{t=0\,s} = 1.5(0^3) - 13.5(0^2) + 22.5(0) = 0$$

$$s|_{t=1\,s} = 1.5(1^3) - 13.5(1^2) + 22.5(1) = 10.5 \text{ ft}$$

$$s|_{t=5\,s} = 1.5(5^3) - 13.5(5^2) + 22.5(5) = -37.5 \text{ ft}$$

From the particle's path, the total distance is

$$s_{tot} = 10.5 + 48.0 + 10.5 = 69.0 \text{ ft} \qquad \textbf{Ans.}$$

12–11.

If a particle has an initial velocity of $v_0 = 12\ \text{ft/s}$ to the right, at $s_0 = 0$, determine its position when $t = 10\ \text{s}$, if $a = 2\ \text{ft/s}^2$ to the left.

SOLUTION

$$\left(\overset{+}{\rightarrow}\right) \qquad s = s_0 + v_0 t + \frac{1}{2} a_c t^2$$

$$= 0 + 12(10) + \frac{1}{2}(-2)(10)^2$$

$$= 20\ \text{ft}$$

Ans.

***12–12.**

Determine the time required for a car to travel 1 km along a road if the car starts from rest, reaches a maximum speed at some intermediate point, and then stops at the end of the road. The car can accelerate at $1.5\ \text{m/s}^2$ and decelerate at $2\ \text{m/s}^2$.

SOLUTION

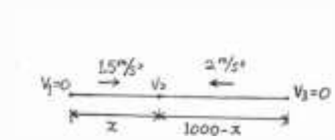
Using formulas of constant acceleration:

$v_2 = 1.5\,t_1$

$x = \frac{1}{2}(1.5)(t_1^2)$

$0 = v_2 - 2\,t_2$

$1000 - x = v_2 t_2 - \frac{1}{2}(2)(t_2^2)$



Combining equations:

$t_1 = 1.33\,t_2; \quad v_2 = 2\,t_2$

$x = 1.33\,t_2^2$

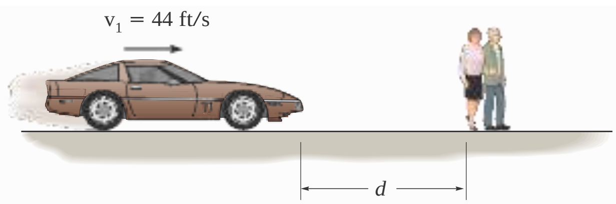
$1000 - 1.33\,t_2^2 = 2\,t_2^2 - t_2^2$

$t_2 = 20.702\ \text{s}; \qquad t_1 = 27.603\ \text{s}$

$t = t_1 + t_2 = 48.3\ \text{s}$ **Ans.**

12–13.

Tests reveal that a normal driver takes about 0.75 s before he or she can *react* to a situation to avoid a collision. It takes about 3 s for a driver having 0.1% alcohol in his system to do the same. If such drivers are traveling on a straight road at 30 mph (44 ft>s) and their cars can decelerate at 2 ft>s^2, determine the shortest stopping distance *d* for each from the moment they see the pedestrians. *Moral*: If you must drink, please don't drive!



SOLUTION

Stopping Distance: For normal driver, the car moves a distance of d¿ = vt = 44(0.75) = 33.0 ft before he or she reacts and decelerates the car. The stopping distance can be obtained using Eq. 12–6 with s_0 = d¿ = 33.0 ft and $v = 0$.

A ± B $\qquad v^2 = v_0^2 + 2a_c(s - s_0)$

$$0^2 = 44^2 + 2(-2)(d - 33.0)$$
$$d = 517 \text{ ft} \qquad \textbf{Ans.}$$

For a drunk driver, the car moves a distance of d¿ = vt = 44(3) = 132 ft before he or she reacts and decelerates the car. The stopping distance can be obtained using Eq. 12–6 with s_0 = d¿ = 132 ft and $v = 0$.

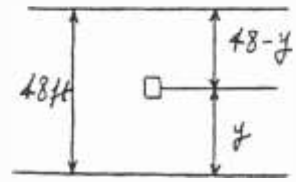
A ± B $\qquad v^2 = v_0^2 + 2a_c(s - s_0)$

$$0^2 = 44^2 + 2(-2)(d - 132)$$
$$d = 616 \text{ ft} \qquad \textbf{Ans.}$$

12–14.

A car is to be hoisted by elevator to the fourth floor of a parking garage, which is 48 ft above the ground. If the elevator can accelerate at 0.6 ft>s^2, decelerate at 0.3 ft>s^2, and reach a maximum speed of 8 ft>s, determine the shortest time to make the lift, starting from rest and ending at rest.

SOLUTION



$+c \quad v^2 = v_0^2 + 2a_c(s - s_0)$

$v_{max}^2 = 0 + 2(0.6)(y - 0)$

$0 = v_{max}^2 + 2(-0.3)(48 - y)$

$0 = 1.2y - 0.6(48 - y)$

$y = 16.0 \text{ ft}, \qquad v_{max} = 4.382 \text{ ft>s} \; 6 \; 8 \text{ ft>s}$

$+c \quad v = v_0 + a_c t$

$4.382 = 0 + 0.6t_1$

$t_1 = 7.303 \text{ s}$

$0 = 4.382 - 0.3t_2$

$t_2 = 14.61 \text{ s}$

$t = t_1 + t_2 = 21.9 \text{ s}$ **Ans.**

12–15.

A train starts from rest at station A and accelerates at 0.5 m>s^2 for 60 s. Afterwards it travels with a constant velocity for 15 min. It then decelerates at 1 m>s^2 until it is brought to rest at station B. Determine the distance between the stations.

SOLUTION

Kinematics: For stage (1) motion, $v_0 = 0$, $s_0 = 0$, $t = 60$ s, and $a_c = 0.5 \text{ m>s}^2$. Thus,

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

$$s_1 = 0 + 0 + \frac{1}{2}(0.5)(60^2) = 900 \text{ m}$$

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

$$v_1 = 0 + 0.5(60) = 30 \text{ m>s}$$

For stage (2) motion, $v_0 = 30 \text{ m>s}$, $s_0 = 900$ m, $a_c = 0$ and $t = 15(60) = 900$ s. Thus,

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

$$s_2 = 900 + 30(900) + 0 = 27\,900 \text{ m}$$

For stage (3) motion, $v_0 = 30 \text{ m>s}$, $v = 0$, $s_0 = 27\,900$ m and $a_c = -1 \text{ m>s}^2$. Thus,

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

$$0 = 30 + (-1)t$$

$$t = 30 \text{ s}$$

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

$$s_3 = 27\,900 + 30(30) + \frac{1}{2}(-1)(30^2)$$

$$= 28\,350 \text{ m} = 28.4 \text{ km}$$ **Ans.**

***12–16.**

A particle travels along a straight line such that in 2 s it moves from an initial position $s_A = +0.5$ m to a position $s_B = -1.5$ m. Then in another 4 s it moves from s_B to $s_C = +2.5$ m. Determine the particle's average velocity and average speed during the 6-s time interval.

SOLUTION

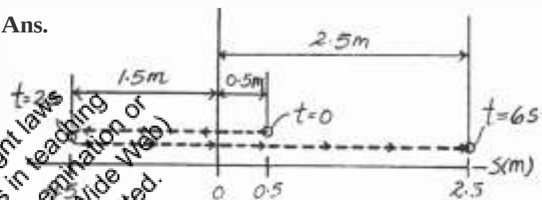
$\Delta s = (s_C - s_A) = 2$ m

$s_T = (0.5 + 1.5 + 1.5 + 2.5) = 6$ m

$t = (2 + 4) = 6$ s

$$v_{avg} = \frac{\Delta s}{t} = \frac{2}{6} = 0.333 \text{ m/s}$$ **Ans.**

$$(v_{sp})_{avg} = \frac{s_T}{t} = \frac{6}{6} = 1 \text{ m/s}$$ **Ans.**



12–17.

The acceleration of a particle as it moves along a straight line is given by $a = 12t - 12\ \text{m>s}^2$, where *t* is in seconds. If $s = 1\ \text{m}$ and $v = 2\ \text{m>s}$ when $t = 0$, determine the particle's velocity and position when $t = 6\ \text{s}$. Also, determine the total distance the particle travels during this time period.

SOLUTION

$$\int_2^v dv = \int_0^t (2t - 1)\,dt$$

$$v = t^2 - t + 2$$

$$\int_1^s ds = \int_0^t (t^2 - t + 2)\,dt$$

$$s = \frac{1}{3}t^3 - \frac{1}{2}t^2 + 2t + 1$$

When $t = 6$ s,

$$v = 32\ \text{m>s}$$ **Ans.**

$$s = 67\ \text{m}$$ **Ans.**

Since $v \neq 0$ then

$$d = 67 - 1 = 66\ \text{m}$$ **Ans.**

12–18.

A freight train travels at $v = 60(1 - e^{-t})$ ft/s, where t is the elapsed time in seconds. Determine the distance traveled in three seconds, and the acceleration at this time.

SOLUTION

$v = 60(1 - e^{-t})$

$$\int_0^s ds = \int v\,dt = \int_0^3 60(1 - e^{-t})\,dt$$

$s = 60(t + e^{-t})\big|_0^3$

$s = 123$ ft **Ans.**

$$a = \frac{dv}{dt} = 60(e^{-t})$$

At $t = 3$ s

$a = 60e^{-3} = 2.99$ ft/s^2 **Ans.**

12–19.

A particle travels to the right along a straight line with a velocity $v = [5/(4 + s)]$ m/s, where s is in meters. Determine its position when $t = 6$ s if $s = 5$ m when $t = 0$.

SOLUTION

$$\frac{ds}{dt} = \frac{5}{4 + s}$$

$$\int_5^s (4 + s)\, ds = \int_0^t 5\, dt$$

$$4 s + 0.5 s^2 - 32.5 = 5 t$$

When $t = 6$ s,

$$s^2 + 8 s - 125 = 0$$

Solving for the positive root

$s = 7.87$ m **Ans.**

***12–20.**

The velocity of a particle traveling along a straight line is $v = (3t^2 - 6t)$ ft/s, where t is in seconds. If $s = 4$ ft when $t = 0$, determine the position of the particle when $t = 4$ s. What is the total distance traveled during the time interval $t = 0$ to $t = 4$ s? Also, what is the acceleration when $t = 2$ s?

SOLUTION

Position: The position of the particle can be determined by integrating the kinematic equation $ds = v\,dt$ using the initial condition $s = 4$ ft when $t = 0$ s. Thus,

$$(\overset{+}{\rightarrow}) \qquad ds = v\,dt$$

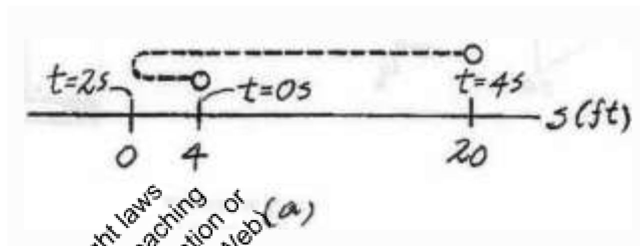
$$\int_{4\text{ ft}}^{s} ds = \int_0^t \left(3t^2 - 6t\right)dt$$

$$s\Big|_{4\text{ ft}}^{s} = \left(t^3 - 3t^2\right)\Big|_0^t$$

$$s = \left(t^3 - 3t^2 + 4\right)\text{ ft}$$

When $t = 4$ s,

$$s|_{4\text{ s}} = 4^3 - 3(4^2) + 4 = 20\text{ ft}$$ **Ans.**



The velocity of the particle changes direction at the instant when it is momentarily brought to rest. Thus,

$$v = 3t^2 - 6t = 0$$

$$t(3t - 6) = 0$$

$$t = 0 \text{ and } t = 2\text{ s}$$

The position of the particle at $t = 0$ and 2 s is

$$s|_{0\text{ s}} = 0 - 3\left(0^2\right) + 4 = 4\text{ ft}$$

$$s|_{2\text{ s}} = 2^3 - 3\left(2^2\right) + 4 = 0$$

Using the above result, the path of the particle shown in Fig. *a* is plotted. From this figure,

$$s_{Tot} = 4 + 20 = 24\text{ ft}$$ **Ans.**

Acceleration:

$$(\overset{+}{\rightarrow}) \qquad a = \frac{dv}{dt} = \frac{d}{dt}\left(3t^2 - 6t\right)$$

$$a = (6t - 6)\text{ ft/s}^2$$

When $t = 2$ s,

$$a|_{t=2\text{ s}} = 6(2) - 6 = 6\text{ ft/s}^2 \rightarrow$$ **Ans.**

12–21.

If the effects of atmospheric resistance are accounted for, a falling body has an acceleration defined by the equation $a = 9.81[1 - v^2(10^{-4})]$ m/s^2, where v is in m/s and the positive direction is downward. If the body is released from rest at a *very high altitude*, determine (a) the velocity when $t = 5$ s, and (b) the body's terminal or maximum attainable velocity (as $t \to \infty$).

SOLUTION

Velocity: The velocity of the particle can be related to the time by applying Eq. 12–2.

$$(+\downarrow) \qquad dt = \frac{dv}{a}$$

$$\int_0^t dt = \int_0^v \frac{dv}{9.81[1 - (0.01v)^2]}$$

$$t = \frac{1}{9.81}\left[\int_0^v \frac{dv}{2(1 + 0.01v)} + \int_0^v \frac{dv}{2(1 - 0.01v)}\right]$$

$$9.81t = 50\ln\left(\frac{1 + 0.01v}{1 - 0.01v}\right)$$

$$v = \frac{100(e^{0.1962t} - 1)}{e^{0.1962t} + 1} \qquad (1)$$

a) When $t = 5$ s, then, from Eq. (1)

$$v = \frac{100[e^{0.1962(5)} - 1]}{e^{0.1962(5)} + 1} = 45.5 \text{ m/s}$$ **Ans.**

b) If $t \to \infty$, $\dfrac{e^{0.1962t} - 1}{e^{0.1962t} + 1} \to 1$. Then, from Eq. (1)

$$v_{max} = 100 \text{ m/s}$$ **Ans.**

12–22.

The position of a particle on a straight line is given by $s = 1t^3 - 9t^2 + 15t2$ ft, where t is in seconds. Determine the position of the particle when $t = 6$ s and the total distance it travels during the 6-s time interval. *Hint*: Plot the path to determine the total distance traveled.

SOLUTION

$s = t^3 - 9t^2 + 15t$

$v = \frac{ds}{dt} = 3t^2 - 18t + 15$

$v = 0$ when $t = 1$ s and $t = 5$ s

$t = 0, \ s = 0$

$t = 1$ s, $s = 7$ ft

$t = 5$ s, $s = -25$ ft

$t = 6$ s, $s = -18$ ft **Ans.**

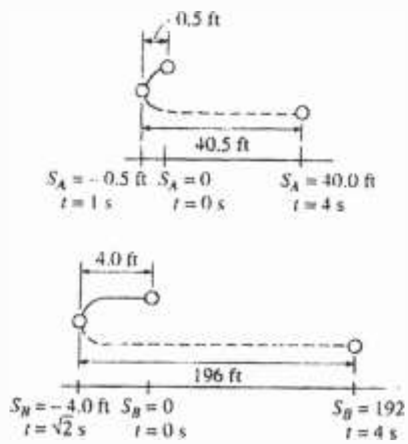
$s_T = 7 + 7 + 25 + (25 - 18) = 46$ ft **Ans.**

12–23.

Two particles A and B start from rest at the origin $s = 0$ and move along a straight line such that $a_A = (6t - 3)$ ft>s^2 and $a_B = (12t^2 - 8)$ ft>s^2, where t is in seconds. Determine the distance between them when $t = 4$ s and the total distance each has traveled in $t = 4$ s.

SOLUTION

Velocity: The velocity of particles A and B can be determined using Eq. 12-2.



$$dv_A = a_A dt$$

$$\int_0^{v_A} dv_A = \int_0^t (6t - 3)dt$$

$$v_A = 3t^2 - 3t$$

$$dv_B = a_B dt$$

$$\int_0^{v_B} dv_B = \int_0^t (12t^2 - 8)dt$$

$$v_B = 4t^3 - 8t$$

The times when particle A stops are

$3t^2 - 3t = 0 \qquad t = 0$ s and $= 1$ s

The times when particle B stops are

$4t^3 - 8t = 0 \quad t = 0$ s and $t = \sqrt{2}$ s

Position: The position of particles A and B can be determined using Eq. 12-2.

$$ds_A = v_A dt$$

$$\int_0^{s_A} ds_A = \int_0^t (3t^2 - 3t)dt$$

$$s_A = t^3 - \frac{3}{2}t^2$$

$$ds_B = v_B dt$$

$$\int_0^{s_B} ds_B = \int_0^t (4t^3 - 8t)dt$$

$$s_B = t^4 - 4t^2$$

The positions of particle A at $t = 1$ s and 4 s are

$$s_A|_{t=1\text{ s}} = 1^3 - \frac{3}{2}(1^2) = -0.500 \text{ ft}$$

$$s_A|_{t=4\text{ s}} = 4^3 - \frac{3}{2}(4^2) = 40.0 \text{ ft}$$

Particle A has traveled

$$d_A = 2(0.5) + 40.0 = 41.0 \text{ ft}$$ **Ans.**

The positions of particle B at $t = \sqrt{2}$ s and 4 s are

$$s_B|_{t=\sqrt{2}} = (\sqrt{2})^4 - 4(\sqrt{2})^2 = -4 \text{ ft}$$

$$s_B|_{t=4} = (4)^4 - 4(4)^2 = 192 \text{ ft}$$

Particle B has traveled

$$d_B = 2(4) + 192 = 200 \text{ ft}$$

At $t = 4$ s the distance beween A and B is

$¢s_{AB} = 192 - 40 = 152$ ft **Ans.**

Ans.

***12–24.**

A particle is moving along a straight line such that its velocity is defined as $v = (-4s^2)$ m>s, where s is in meters. If $s = 2$ m when $t = 0$, determine the velocity and acceleration as functions of time.

SOLUTION

$$v = -4s^2$$

$$\frac{ds}{dt} = -4s^2$$

$$\int_2^s s^{-2}\,ds = \int_0^t -4\,dt$$

$$-s^{-1}\Big|_2^s = -4t\Big|_0^t$$

$$t = \frac{1}{4}(s^{-1} - 0.5)$$

$$s = \frac{2}{8t + 1}$$

$$v = -4\left(\frac{2}{8t+1}\right)^2 = -\frac{16}{(8t+1)^2} \text{ m>s}$$ **Ans.**

$$a = \frac{dv}{dt} = \frac{16(2)(8t+1)(8)}{(8t+1)^4} = \frac{256}{(8t+1)^3} \text{ m>s}^2$$ **Ans.**

12–25.

A sphere is fired downwards into a medium with an initial speed of 27 m>s. If it experiences a deceleration of $a = (-6t)\ \text{m/s}^2$, where t is in seconds, determine the distance traveled before it stops.

SOLUTION

Velocity: $v_0 = 27$ m>s at $t_0 = 0$ s. Applying Eq. 12–2, we have

$$(+\downarrow) \qquad dv = a\,dt$$

$$\int_{27}^{v} dv = \int_0^t -6t\,dt$$

$$v = \left(27 - 3t^2\right)\ \text{m/s} \qquad \textbf{(1)}$$

At $v = 0$, from Eq. (1)

$$0 = 27 - 3t^2 \qquad t = 3.00\ \text{s}$$

Distance Traveled: $s_0 = 0$ m at $t_0 = 0$ s. Using the result $v = 27 - 3t^2$ and applying Eq. 12–1, we have

$$(+\downarrow) \qquad ds = v\,dt$$

$$\int_0^s ds = \int_0^t \left(27 - 3t^2\right) dt$$

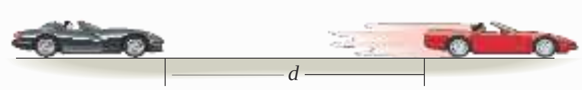
$$s = \left(27t - t^3\right)\ \text{m} \qquad \textbf{(2)}$$

At $t = 3.00$ s, from Eq. (2)

$$s = 27(3.00) - 3.00^3 = 54.0\ \text{m} \qquad \textbf{Ans.}$$

12–26.

When two cars A and B are next to one another, they are traveling in the same direction with speeds v_A and v_B, respectively. If B maintains its constant speed, while A begins to decelerate at a_A, determine the distance d between the cars at the instant A stops.



SOLUTION

Motion of car A:

$$v = v_0 + a_c t$$

$$0 = v_A - a_A t \qquad t = \frac{v_A}{a_A}$$

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

$$0 = v_A^2 + 2(-a_A)(s_A - 0)$$

$$s_A = \frac{v_A^2}{2a_A}$$

Motion of car B:

$$s_B = v_B t = v_B \left(\frac{v_A}{a_A}\right) = \frac{v_A v_B}{a_A}$$

The distance between cars A and B is

$$s_{BA} = |s_B - s_A| = \frac{v_A v_B}{a_A} - \frac{v_A^2}{2a_A} = \frac{2v_A v_B - v_A^2}{2a_A}$$ **Ans.**

12–27.

A particle is moving along a straight line such that when it is at the origin it has a velocity of 4 m/s. If it begins to decelerate at the rate of $a = (-1.5v^{1/2})$ m/s^2, where v is in m/s, determine the distance it travels before it stops.

SOLUTION

$$a = \frac{dv}{dt} = -1.5v^{\frac{1}{2}}$$

$$\int_4^v v^{-\frac{1}{2}}\,dv = \int_0^t -1.5\,dt$$

$$2v^{\frac{1}{2}}\Big|_4^v = -1.5t\Big|_0^t$$

$$2\left(v^{\frac{1}{2}} - 2\right) = -1.5t$$

$$v = (2 - 0.75t)^2 \text{ m/s} \qquad \textbf{(1)}$$

$$\int_0^s ds = \int_0^t (2 - 0.75t)^2\,dt = \int_0^t (4 - 3t + 0.5625t^2)\,dt$$

$$s = 4t - 1.5t^2 + 0.1875t^3 \qquad \textbf{(2)}$$

From Eq. (1), the particle will stop when

$$0 = (2 - 0.75t)^2$$
$$t = 2.667 \text{ s}$$

$$s|_{t=2.667} = 4(2.667) - 1.5(2.667)^2 + 0.1875(2.667)^3 = 3.56 \text{ m} \qquad \textbf{Ans.}$$

***12–28.**

A particle travels to the right along a straight line with a velocity v = [5>14 + s2] m>s, where *s* is in meters.

Determine its deceleration when s = 2 m.

SOLUTION

$$v = \frac{5}{4 + s}$$

$$v\,dv = a\,ds$$

$$dv = \frac{-5\,ds}{(4 + s)^2}$$

$$\frac{5}{(4 + s)}\,a\frac{-5\,ds}{(4 + s)^2}b = a\,ds$$

$$a = \frac{-25}{(4 + s)^3}$$

When $s = 2$ m

$$a = -0.116 \text{ m>s}^2$$

Ans.

Ans.