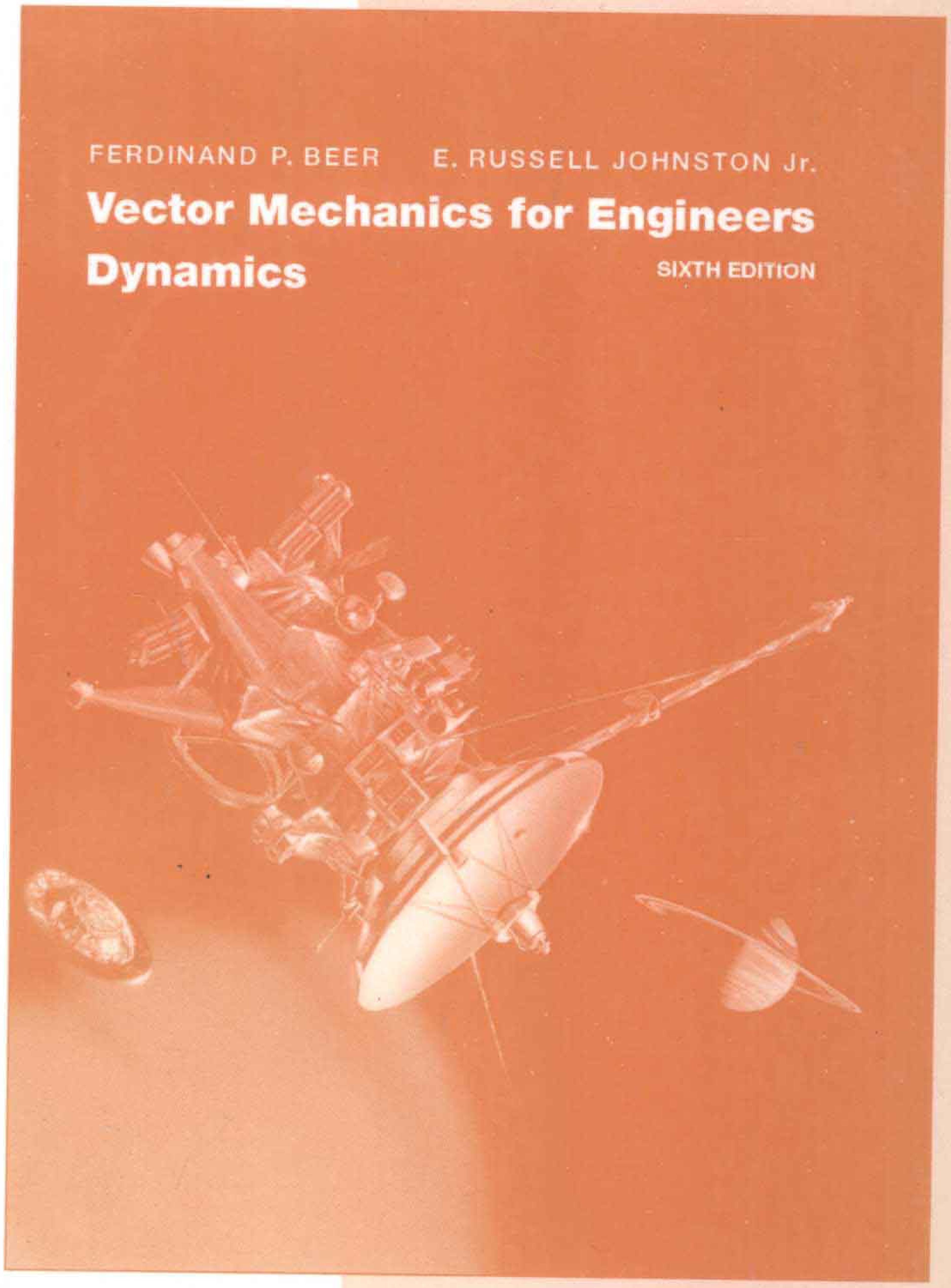
Problems Supplement

to accompany



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Problems Supplement

to accompany

Vector Mechanics for Engineers: Dynamics

Sixth Edition

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CHAPTER 11
KINEMATICS OF PARTICLES

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11.2 The motion of a particle is defined by the relation $x = t^3 - 3t^2 + 6$, where x is expressed in feet and t in seconds. Determine the time, position, and acceleration when $v = 0$.

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11.6 The acceleration of a particle is defined by the relation $a = kt^2$. (*a*) Knowing that $v = -24$ ft/s when $t = 0$ and that $v = +40$ ft/s when $t = 4$ s, determine the constant k. (*b*) Write the equations of motion, knowing also that $x = 6$ ft when $t = 2$ s.

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11.8 The acceleration of a particle is defined by the relation $a = -k/x$. It has been experimentally determined that $v = 4$ m/s when $x = 250$ mm and that $v = 3$ m/s when $x = 500$ mm. Determine (*a*) the velocity of the particle when $x = 750$ mm, (*b*) the position of the particle at which its velocity is zero.

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11.13 The acceleration of a particle is defined by the relation $a = -kv^{1.5}$. The particle starts at $t = 0$ and $x = 0$ with an initial velocity v_0. (a) Show that the velocity and position coordinate at any time t are related by the equation $x/t = \sqrt{v_0 v}$. (b) Knowing that for $v_0 = 36$ m/s the particle comes to rest after traveling 3 m, determine the velocity of the particle and the time when $x = 2$ m.

11.14 The velocity of a particle is defined by the relation $v = 40 - 0.2x$, where v is expressed in m/s and x in meters. Knowing that $x = 0$ at $t = 0$, determine (a) the distance traveled before the particle comes to rest, (b) the acceleration at $t = 0$, (c) the time when $x = 50$ m.

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SECTIONS 11.4 to 11.6

11.17 A ball is thrown vertically upward from a point on a tower located 25 m above the ground. Knowing that the ball strikes the ground 3 s after release, determine the speed with which the ball (a) was thrown upward, (b) strikes the ground.

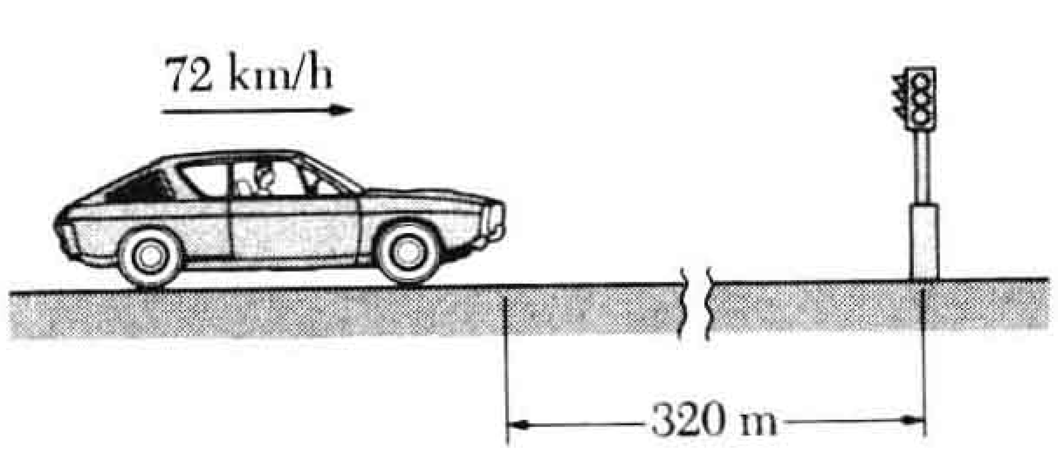

Fig. P11.18

11.18 A motorist is traveling at 72 km/h when she observes that a traffic light 320 m ahead of her turns red. The traffic light is timed to stay red for 22 s. If the motorist wishes to pass the light without stopping just as it turns green again, determine (a) the required uniform deceleration of the car, (b) the speed of the car as it passes the light.

11.19 An automobile travels 800 ft in 20 s while being accelerated at a constant rate of 2.5 ft/s². Determine (*a*) its initial velocity, (*b*) its final velocity, (*c*) the distance traveled during the first 10 s.

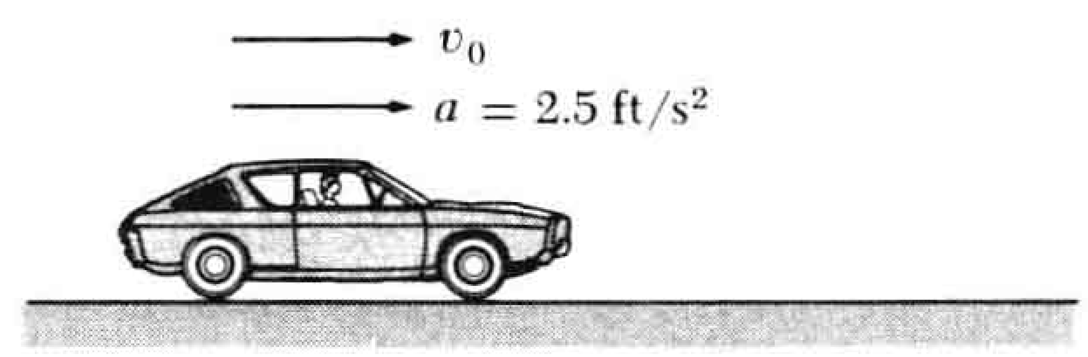

Fig. P11.19

11. 20 A stone is released from an elevator moving up at a speed of 12 ft/s and reaches the bottom of the shaft in 2.5 s. (*a*) How high was the elevator when the stone was released? (*b*) With what speed does the stone strike the bottom of the shaft?

11.21 A bus is accelerated at the rate of 1.2 m/s² as it travels from *A* to *B*. Knowing that the speed of the bus was $v_0 = 18$ km/h as it passed *A*, determine (*a*) the time required for the bus to reach *B*, (*b*) the corresponding speed as it passes *B*.

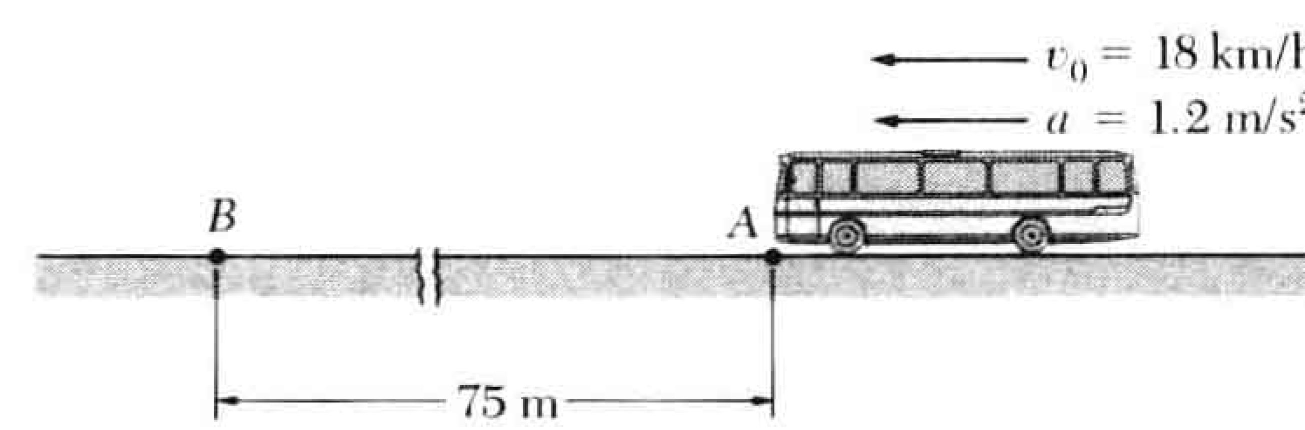

Fig. P11.21

11.22 Automobile *A* starts from *O* and accelerates at the constant rate of 0.8 m/s². A short time later it is passed by bus *B* which is traveling in the opposite direction at a constant speed of 5 m/s. Knowing that bus *B* passes point *O* 22 s after automobile *A* started from there, determine when and where the vehicles passed each other.

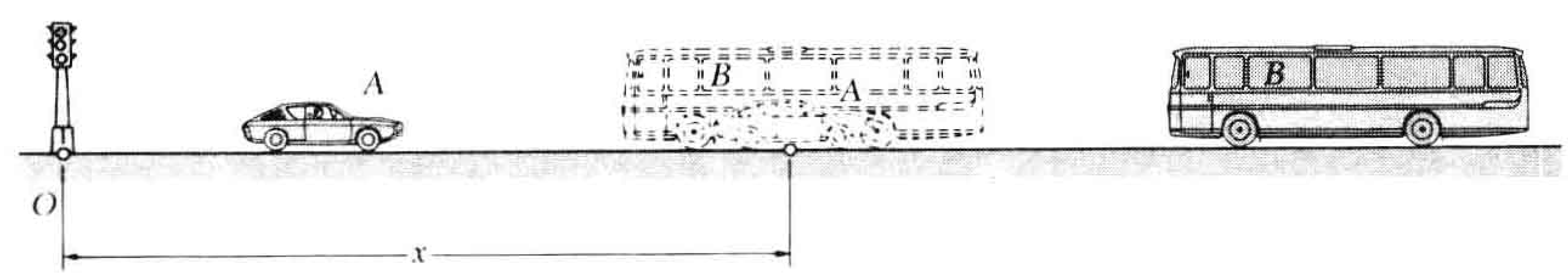

Fig. P11.22

11.23 An open-platform elevator is moving down a mine shaft at a constant velocity v_e when the elevator platform hits and dislodges a stone. (*a*) Assuming that the stone starts falling with no initial velocity, show that the stone will hit the platform with a relative velocity of magnitude v_e. (*b*) If $v_e = 7.5$ m/s, determine when and where the stone will hit the elevator platform.

11.24 A freight elevator moving upward with a constant velocity of 6 ft/s passes a passenger elevator which is stopped. Four seconds later the passenger elevator starts upward with a constant acceleration of 2.4 ft/s². Determine (*a*) when and where the elevators will be at the same height, (*b*) the speed of the passenger elevator at that time.

11.25 Automobiles *A* and *B* are traveling in adjacent highway lanes and at $t = 0$ have the positions and speeds shown. Knowing that automobile *A* has a constant acceleration of 2 ft/s² and that *B* has a constant deceleration of 1.5 ft/s², determine (*a*) when and where *A* will overtake *B*, (*b*) the speed of each automobile at that time.

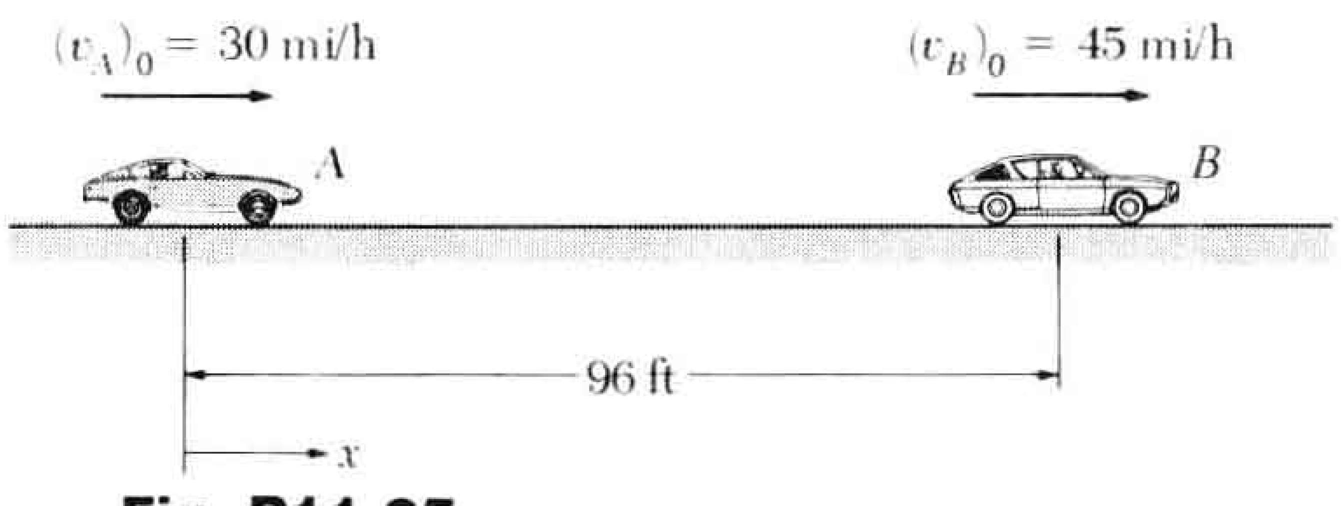

Fig. P11.25

11.26 The elevator shown in the figure moves upward at the constant velocity of 4 m/s. Determine (*a*) the velocity of the cable *C*, (*b*) the velocity of the counterweight *W*, (*c*) the relative velocity of the cable *C* with respect to the elevator, (*d*) the relative velocity of the counterweight *W* with respect to the elevator.

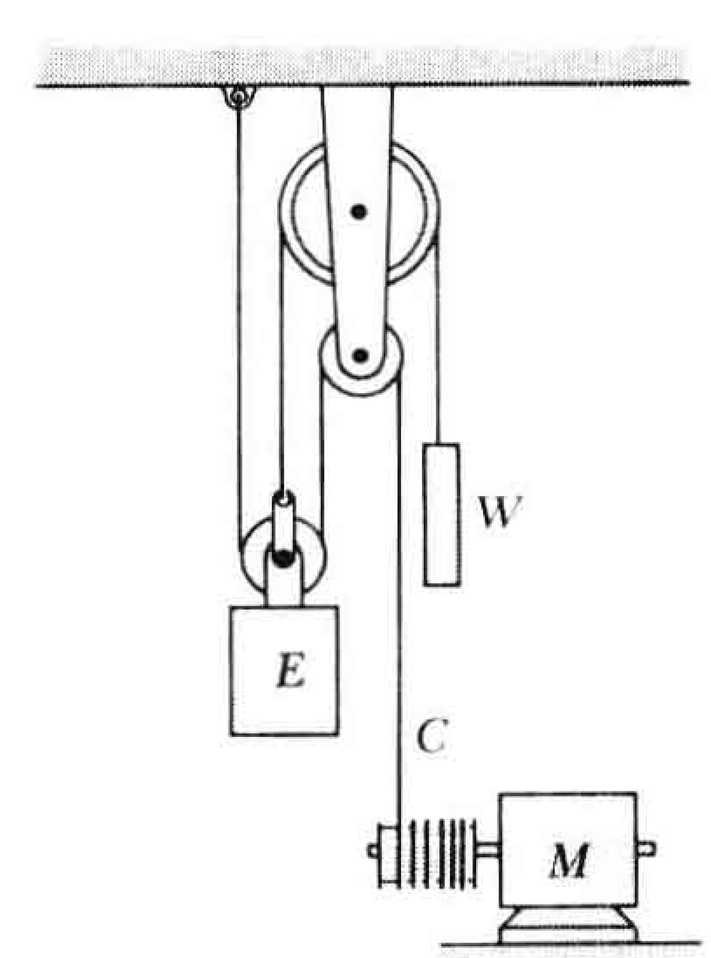

Fig. P11.26

11.27 The slider block *B* moves to the right with a constant velocity of 20 in./s. Determine (*a*) the velocity of block *A*, (*b*) the velocity of portion *D* of the cable, (*c*) the relative velocity of *A* with respect to *B*, (*d*) the relative velocity of portion *C* of the cable with respect to portion *D*.

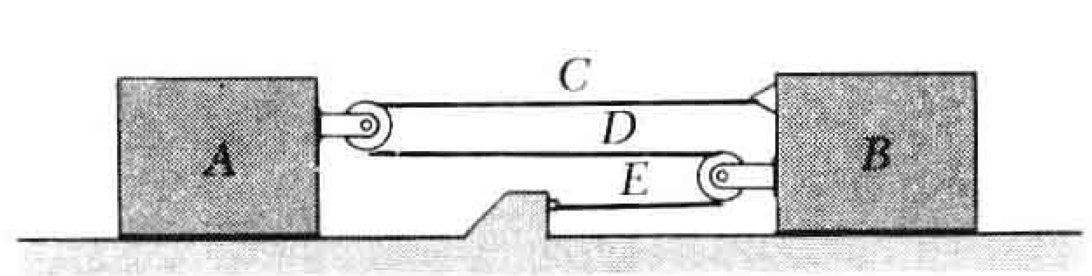

Fig. P11.27

11.28 The slider block A starts from rest and moves to the left with a constant acceleration. Knowing that the velocity of block B is 12 in./s after moving 24 in., determine (a) the accelerations of A and B, (b) the velocity and position of A after 5 s.

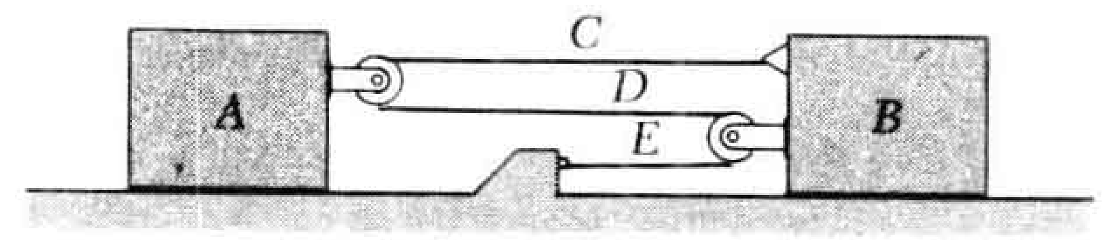

Fig. P11.28

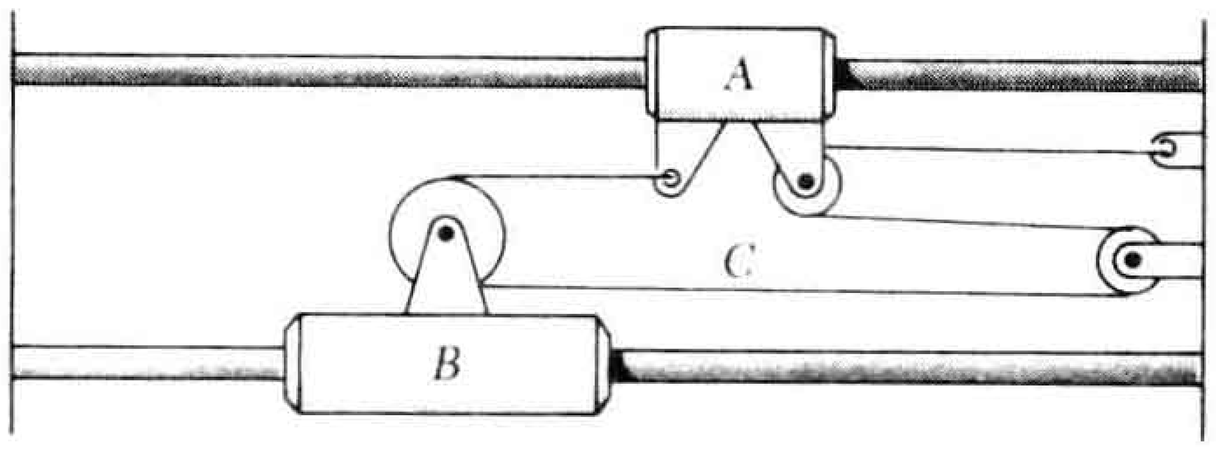

Fig. P11.29

11.29 Collar A starts from rest and moves to the left with a constant acceleration. Knowing that after 4 s the relative velocity of collar B with respect to collar A is 300 mm/s, determine (a) the accelerations of A and B, (b) the position and velocity of B after 5 s.

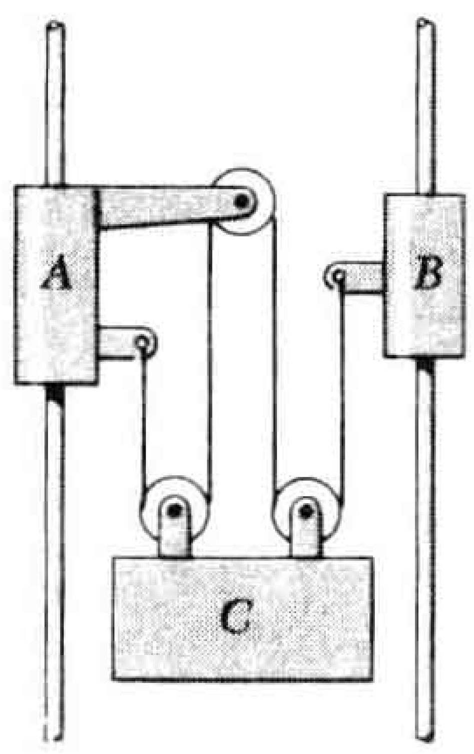

Fig. P11.30 and P11.31

11.30 Collar A starts from rest at $t = 0$ and moves upward with a constant acceleration of 2.5 in./s^2. Knowing that collar B moves downward with a constant velocity of 15 in./s, determine (a) the time at which the velocity of block C is zero, (b) the corresponding position of block C.

11.31 Collars A and B start from rest and move with the following accelerations: $a_A = 3t$ in./s^2 upward and $a_B = 9$ in./s^2 downward. Determine (a) the time at which the velocity of block C is again zero, (b) the distance through which block C will have moved at that time.

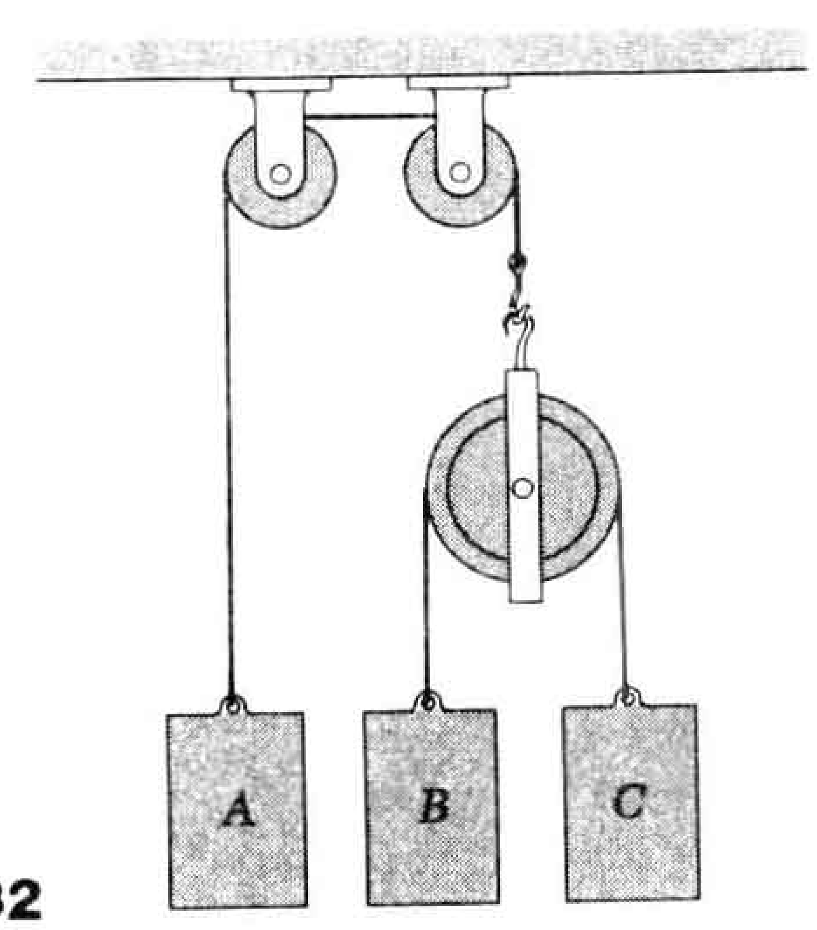

Fig. P11.32

11.32 (a) Choosing the positive sense downward for each block, express the velocity of A in terms of the velocities of B and C. (b) Knowing that both blocks A and C start from rest and move downward with the respective accelerations $a_A = 50$ mm/s^2 and $a_C = 110$ mm/s^2, determine the velocity and position of B after 3 s.

SECTIONS 11.7 to 11.8

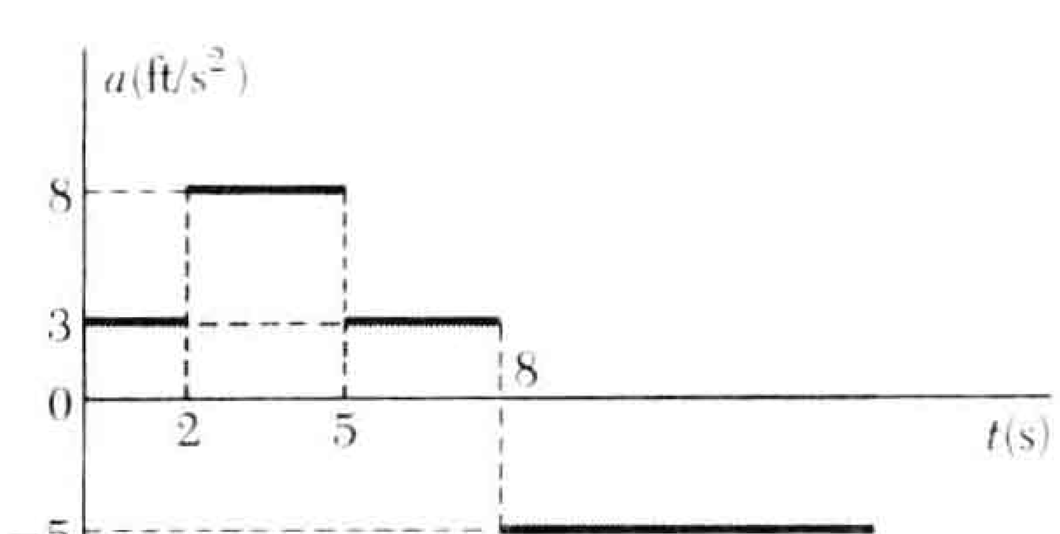

Fig. P11.33

11.33 A particle moves in a straight line with the acceleration shown in the figure. Knowing that it starts from the origin with $v_0 = -14$ ft/s, plot the v–t and x–t curves for $0 < t < 15$ s and determine (a) the maximum value of the velocity of the particle, (b) the maximum value of its position coordinate.

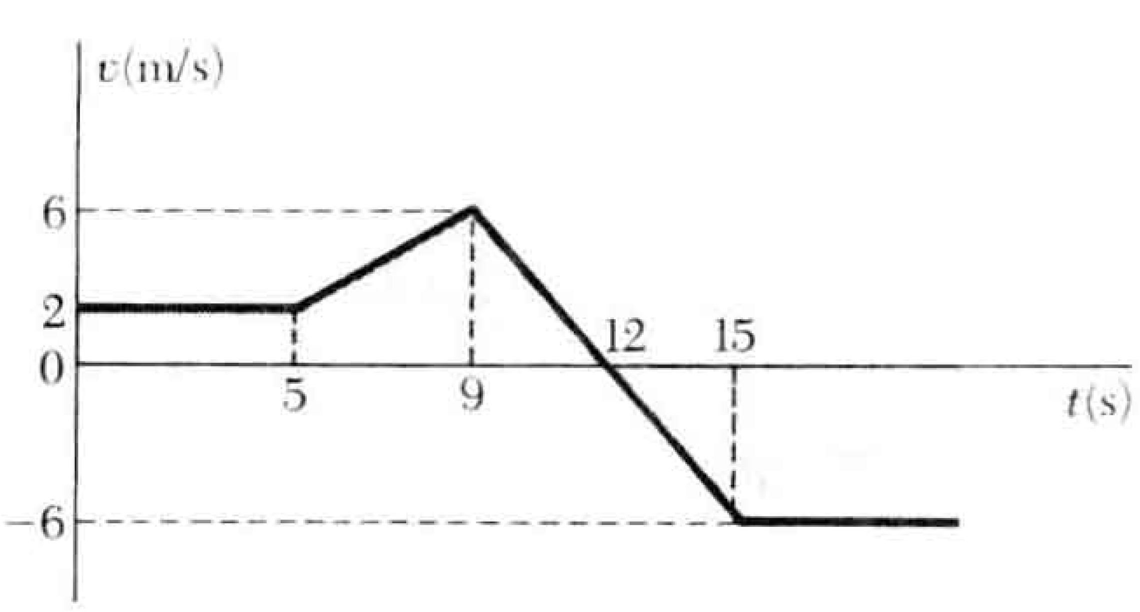

Fig. P11.34

11.34 A particle moves in a straight line with the velocity shown in the figure. Knowing that $x = -8$ m at $t = 0$, draw the a–t and x–t curves for $0 < t < 20$ s and determine (a) the maximum value of the position coordinate of the particle, (b) the values of t for which the particle is at a distance of 18 m from the origin.

11.35 A bus starts from rest at point A and accelerates at the rate of 0.75 m/s^2 until it reaches a speed of 9 m/s. It then proceeds at 9 m/s until the brakes are applied; it comes to rest at point B, 27 m beyond the point where the brakes were applied. Assuming uniform deceleration and knowing that the distance between A and B is 180 m, determine the time required for the bus to travel from A to B.

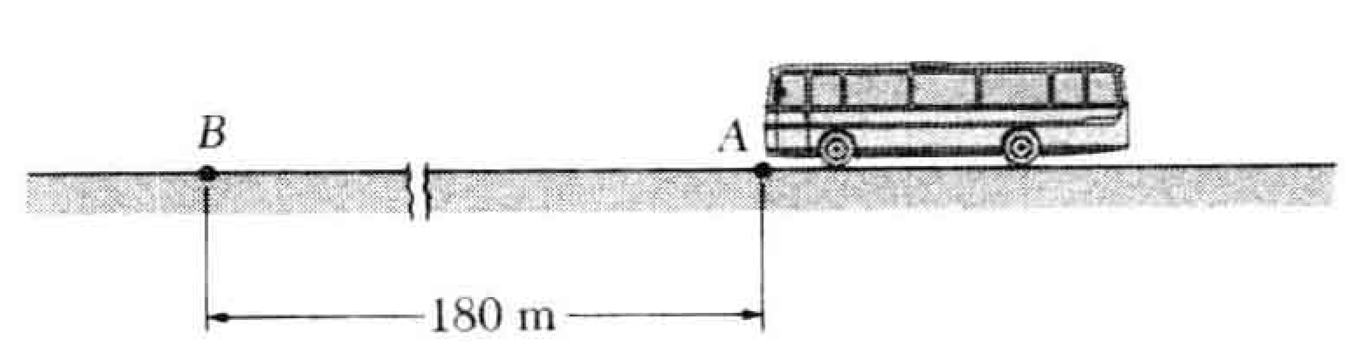

Fig. P11.35

11.36 Firing a howitzer causes the barrel to recoil 42 in. before a braking mechanism brings it to rest. From a high-speed photographic record, it is found that the maximum value of the recoil velocity is 250 in./s and that this is reached 0.02 s after firing. Assuming that the recoil period consists of two phases during which the acceleration has, respectively, a constant positive value a_1 and a constant negative value a_2, determine (*a*) the values of a_1 and a_2, (*b*) the position of the barrel 0.02 s after firing, (*c*) the time at which the velocity of the barrel is zero.

11.37 During a finishing operation the bed of an industrial planer moves alternately 36 in. to the right and 36 in. to the left. The velocity of the bed is limited to a maximum value of 6 in./s to the right and 9 in./s to the left; the acceleration is successively equal to 3 in./s^2 to the right, zero, 3 in./s^2 to the left, zero, etc. Determine the time required for the bed to complete a full cycle, and draw the v–t and x–t curves.

11.38 A motorist is traveling at 72 km/h when she observes that a traffic signal 320 m ahead of her turns red. She knows that the signal is timed to stay red for 22 s. What should she do to pass the signal at 72 km/h just as it turns green again? Draw the v–t curve, selecting the solution which calls for the smallest possible deceleration and acceleration, and determine (*a*) the deceleration and acceleration in m/s^2, (*b*) the minimum speed reached in km/h.

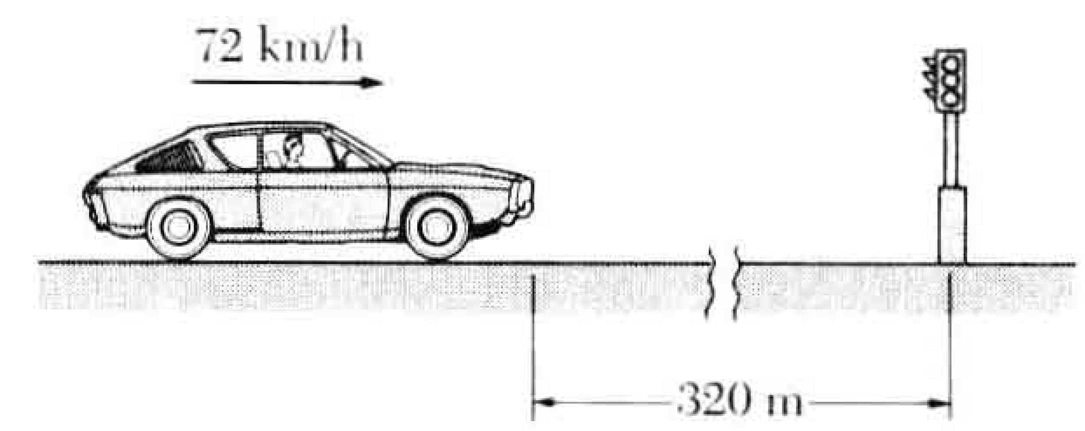

Fig. P11.38

11.39 An automobile at rest is passed by a truck traveling at a constant speed of 54 km/h. The automobile starts and accelerates for 10 s at a constant rate until it reaches a speed of 81 km/h. If the automobile then maintains a constant speed of 81 km/h, determine when and where it will overtake the truck, assuming that the automobile starts (*a*) just as the truck passes it, (*b*) 2 s after the truck has passed it.

11.40 A motorcycle and an automobile are both traveling at the constant speed of 40 mi/h; the motorcycle is 50 ft behind the automobile. The motorcyclist wants to pass the automobile, i.e., he wishes to place his motorcycle at *B*, 50 ft in front of the automobile, and then resume the speed of 40 mi/h. The maximum acceleration of the motorcycle is 6 ft/s^2 and the maximum deceleration obtained by applying the brakes is 18 ft/s^2. What is the shortest time in which the motorcyclist can complete the passing operation if he does not at any time exceed a speed of 55 mi/h? Draw the v–t curve.

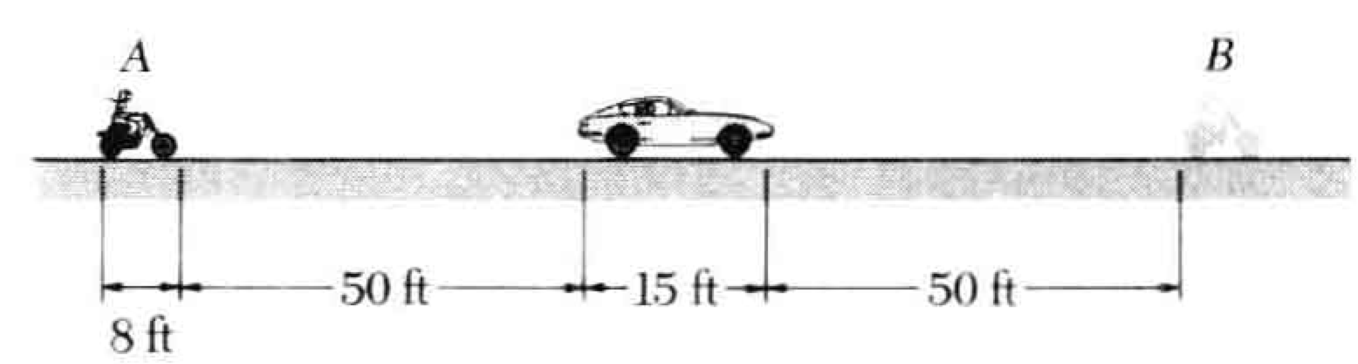

Fig. P11.40

11.41 Car *A* is traveling at the constant speed v_A. It approaches car *B*, which is traveling in the same direction at the constant speed of 63 km/h. The driver of car *B* notices car *A* when it is still 50 m behind him and then accelerates at the constant rate of 0.8 m/s^2 to avoid being passed or struck by car *A*. Knowing that the closest that *A* comes to *B* is 10 m, determine the speed v_A of car *A*.

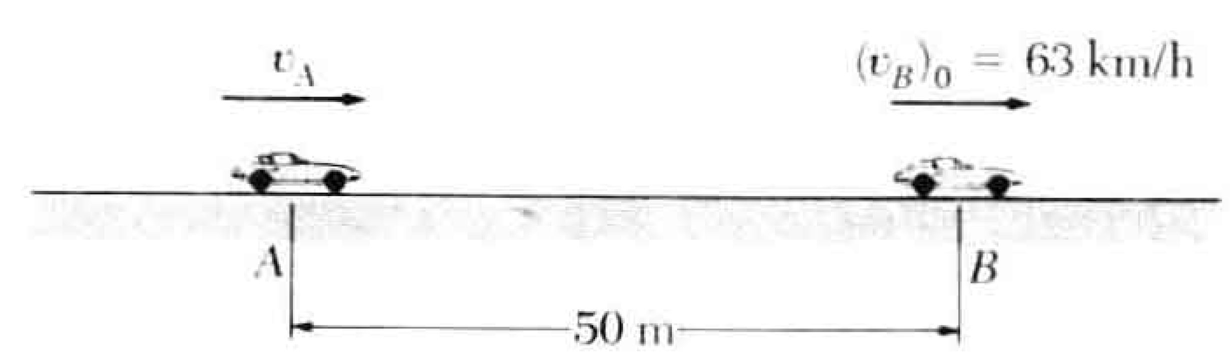

Fig. P11.41

11.42 A fighter plane flying horizontally in a straight line at 900 km/h is overtaking a bomber flying in the same straight line at 720 km/h. The pilot of the fighter plane fires an air-to-air missile at the bomber when his plane is 1150 m behind the bomber. The missile accelerates at a constant rate of 400 m/s^2 for 1 s and then travels at a constant speed. (*a*) How many seconds after firing will the missile reach the bomber? (*b*) If both planes continue at constant speeds, what will be the distance between the planes when the missile strikes the bomber?

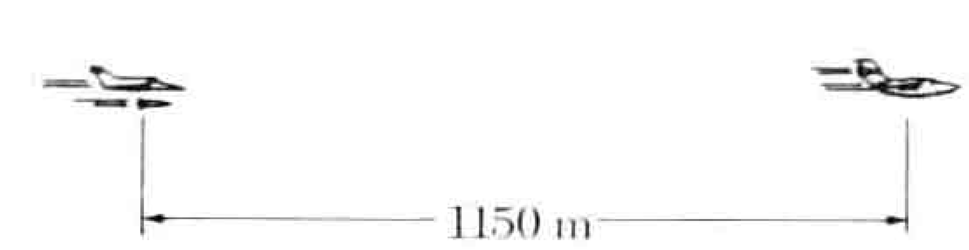

Fig. P11.42

11.43 The acceleration record shown was obtained for a small airplane traveling along a straight course. Knowing that $x = 0$ and $v = 50$ m/s when $t = 0$, determine (*a*) the velocity and position of the plane at $t = 20$ s, (*b*) its average velocity during the interval 6 s $< t <$ 14 s.

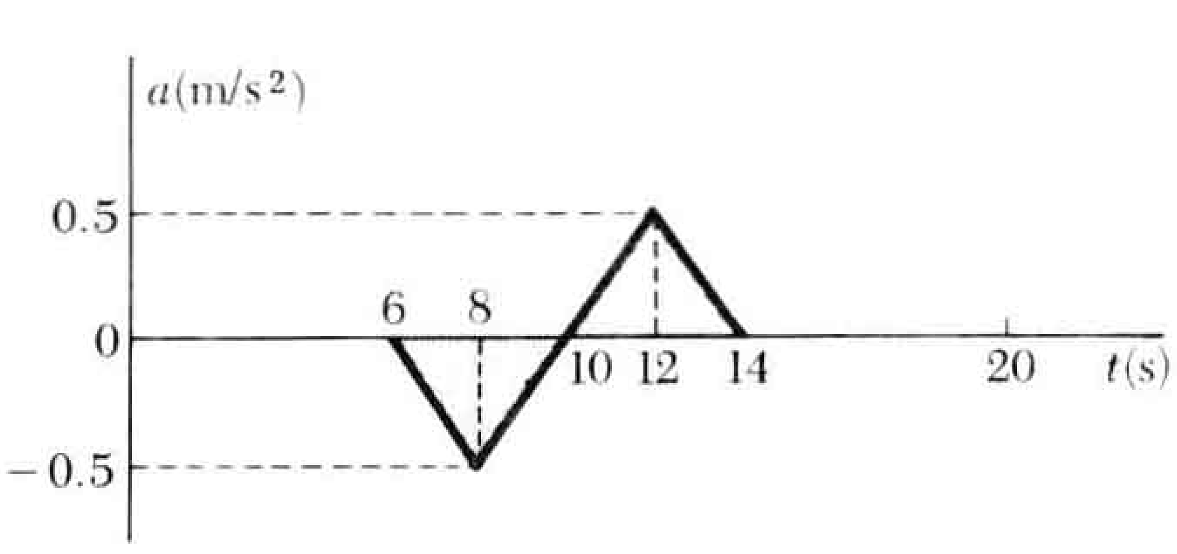

Fig. P11.43

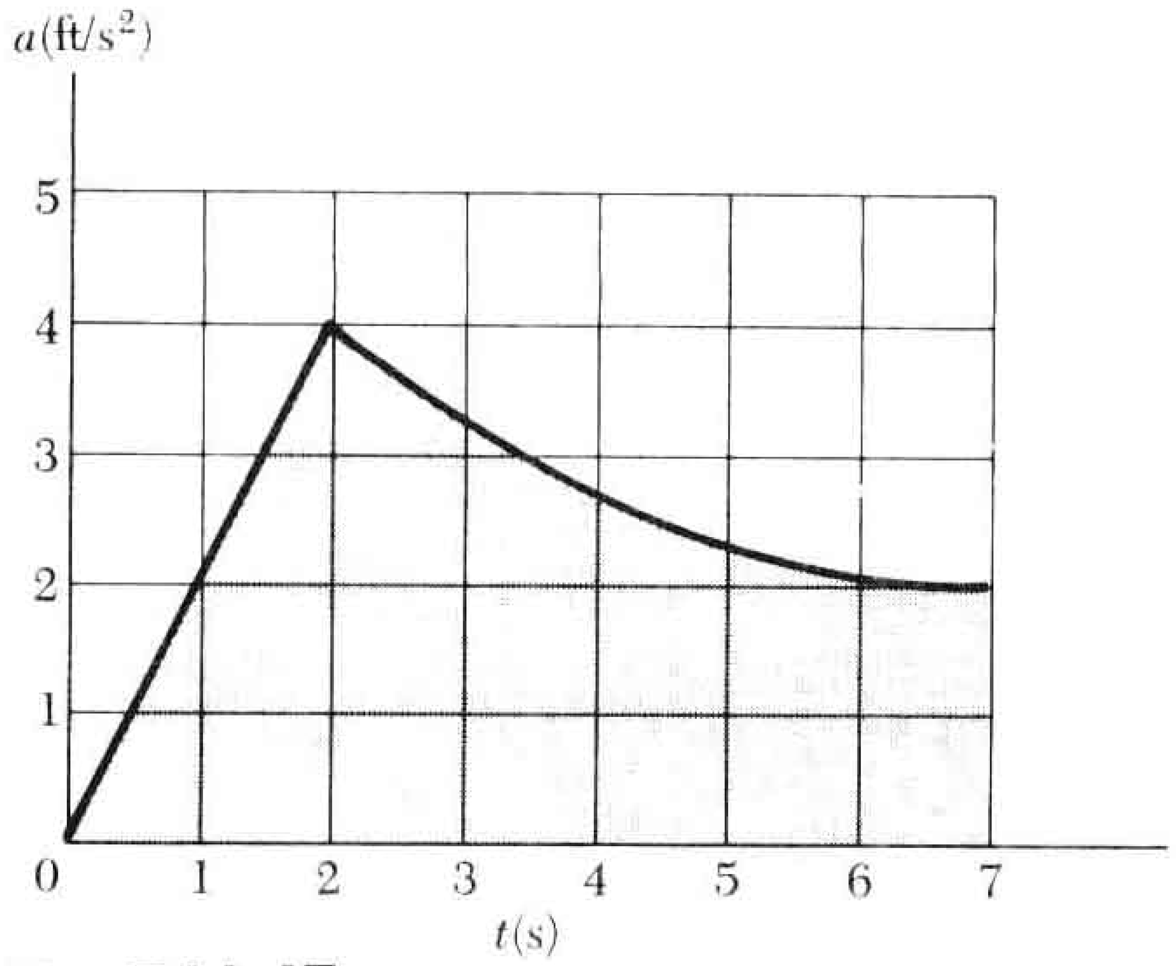

Fig. P11.47

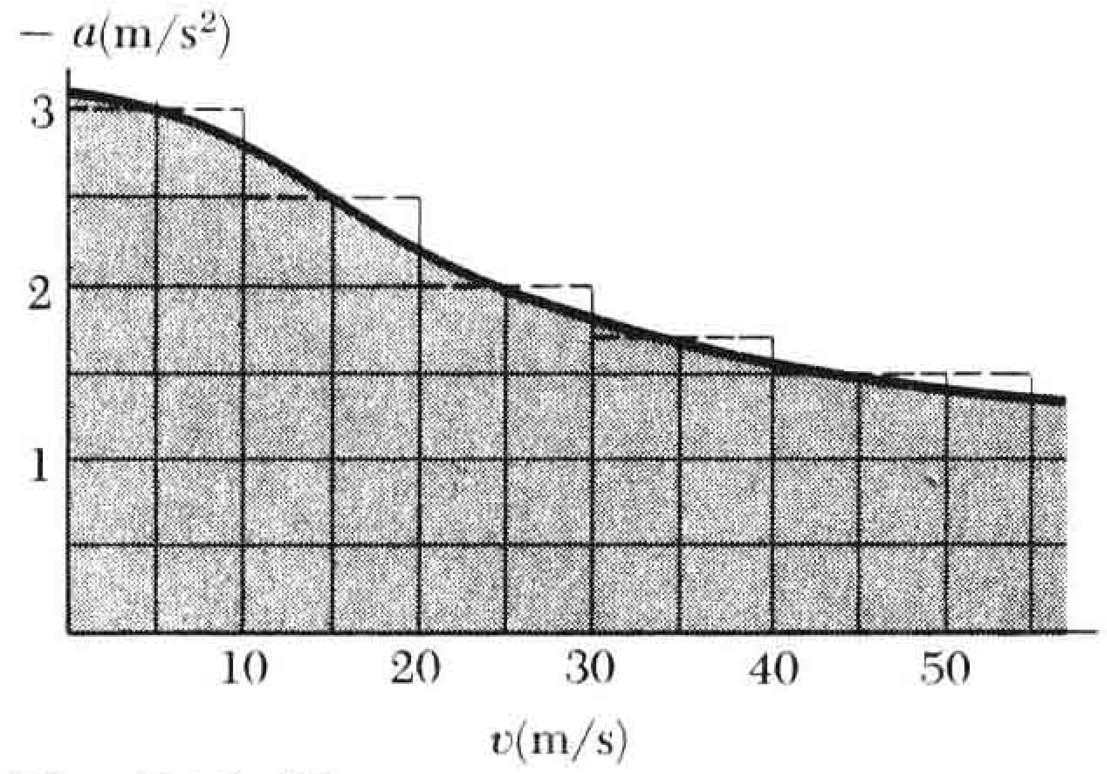

Fig. P11.48

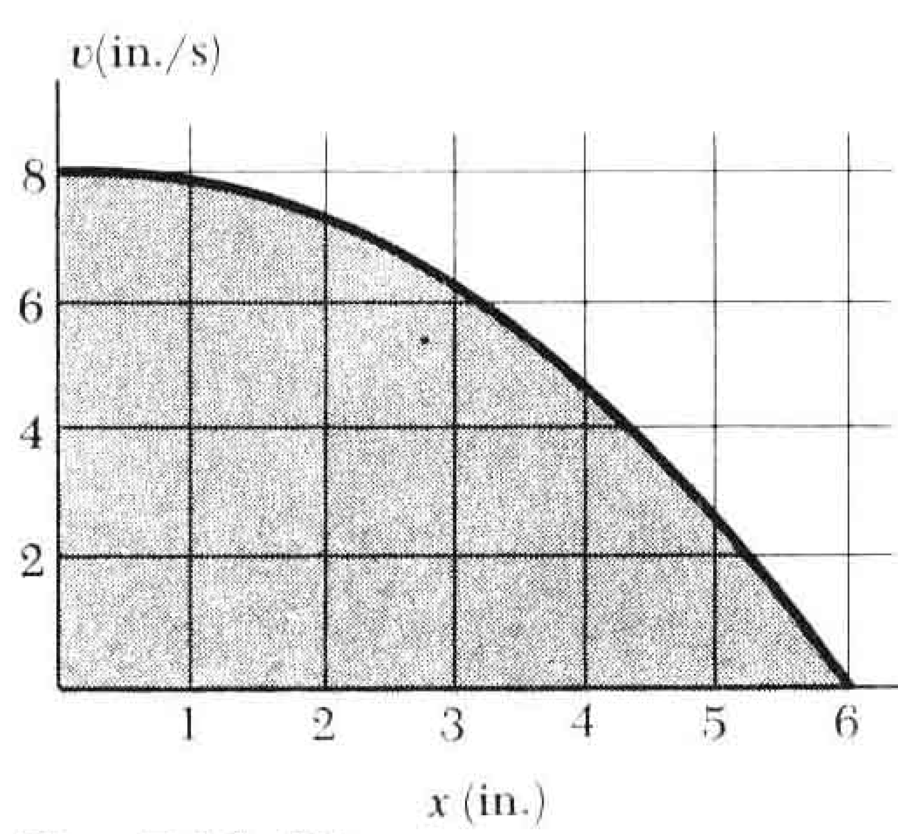

Fig. P11.49

11.44 A train starts at a station and accelerates uniformly at a rate of 1 ft/s^2 until it reaches a speed of 20 ft/s; it then proceeds at the constant speed of 20 ft/s. Determine the time and the distance traveled if its *average* velocity is (*a*) 12 ft/s, (*b*) 18 ft/s.

11.45 The rate of change of acceleration is known as the *jerk;* large or abrupt rates of change of acceleration cause discomfort to elevator passengers. If the jerk, or rate of change of the acceleration, of an elevator is limited to ± 1.5 ft/s^2 per second, determine (*a*) the shortest time required for an elevator, starting from rest, to rise 24 ft and stop, (*b*) the corresponding average velocity of the elevator.

11.46 In order to maintain passenger comfort, the acceleration of an elevator is limited to ± 1.2 m/s^2 and the jerk, or rate of change of acceleration, is limited to ± 0.4 m/s^2 per second. If the elevator starts from rest, determine (*a*) the shortest time required for it to attain a constant velocity of 6 m/s, (*b*) the distance traveled in that time, (*c*) the corresponding average velocity of the elevator.

11.47 The acceleration record shown was obtained for an automobile traveling on a straight highway. Knowing that the initial velocity of the automobile was 15 mi/h, determine the velocity and distance traveled when (*a*) $t = 3$ s, (*b*) $t = 6$ s.

11.48 The maximum possible deceleration of a passenger train under emergency conditions was determined experimentally; the results are shown (solid curve) in the figure. If the brakes are applied when the train is traveling at 108 km/h, determine by approximate means (*a*) the time required for the train to come to rest, (*b*) the distance traveled in that time.

11.49 The v–x curve shown was obtained experimentally during the motion of the bed of an industrial planer. Determine by approximate means the acceleration (*a*) when $x = 3$ in., (*b*) when $v = 4$ in./s.

SECTION 11.9 to 11.12

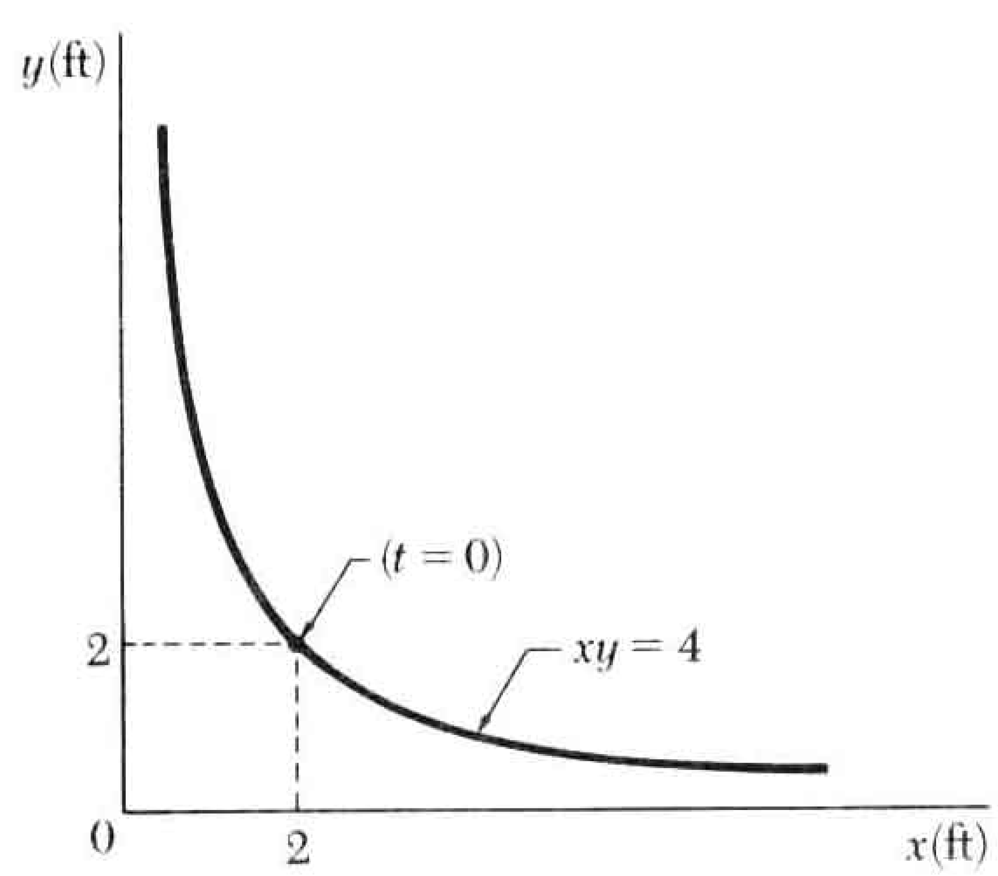

Fig. P11.50

11.50 The motion of a particle is defined by the equations $x = 2(t + 1)^2$ and $y = 2(t + 1)^{-2}$, where x and y are expressed in feet and t in seconds. Show that the path of the particle is part of the rectangular hyperbola shown and determine the velocity and acceleration when (*a*) $t = 0$, (*b*) $t = \frac{1}{2}$ s.

11.51 The motion of a particle is defined by the equations $x = 2t^2 - 4t$ and $y = 2(t - 1)^2 - 4(t - 1)$, where x and y are expressed in meters and t in seconds. Determine (*a*) the magnitude of the smallest velocity reached by the particle, (*b*) the corresponding time, position, and direction of the velocity.

11.52 A particle moves in an elliptic path defined by the position vector $\mathbf{r} = (A \cos pt)\mathbf{i} + (B \sin pt)\mathbf{j}$. Show that the acceleration (*a*) is directed toward the origin, (*b*) is proportional to the distance from the origin to the particle.

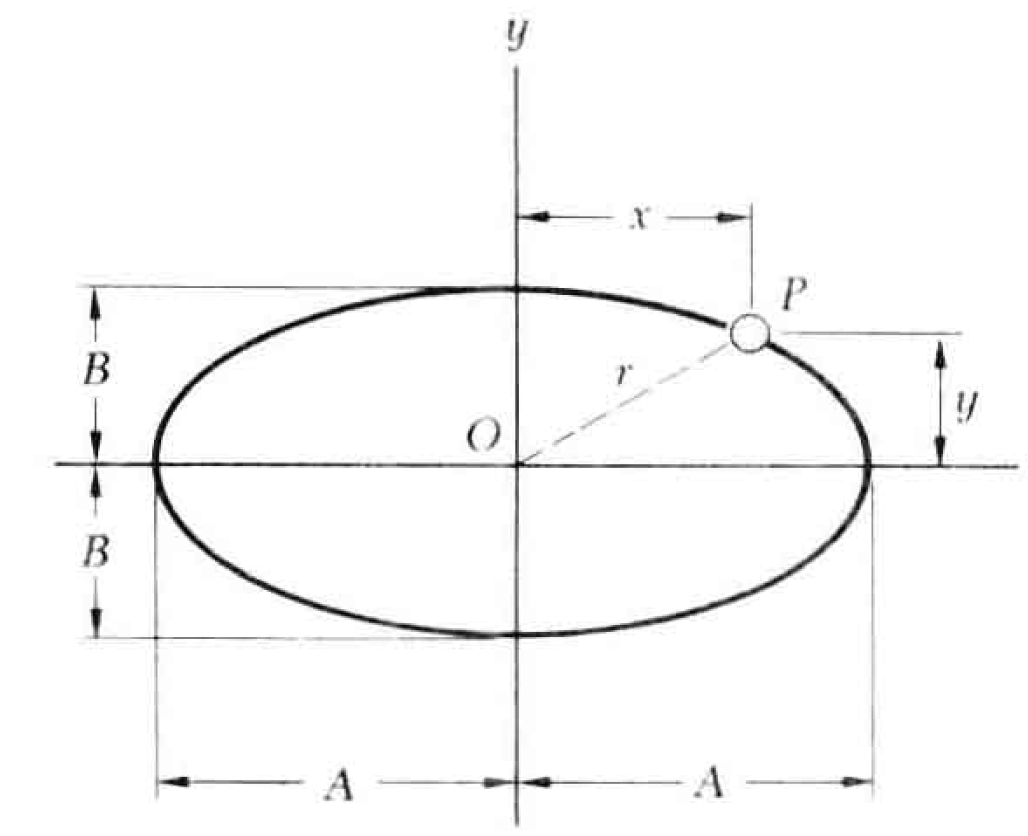

Fig. P11.52

11.53 A man standing at the 18-m level of a tower throws a stone in a horizontal direction. Knowing that the stone hits the ground 25 m from the bottom of the tower, determine (*a*) the initial velocity of the stone, (*b*) the distance at which a stone would hit the ground if it were thrown horizontally with the same velocity from the 22-m level of the tower.

11.54 A handball player throws a ball from *A* with a horizontal velocity $\mathbf{v}_0$. Knowing that $d = 20$ ft, determine (*a*) the value of v_0 for which the ball will strike the corner *C*, (*b*) the range of values of v_0 for which the ball will strike the corner region *BCD*.

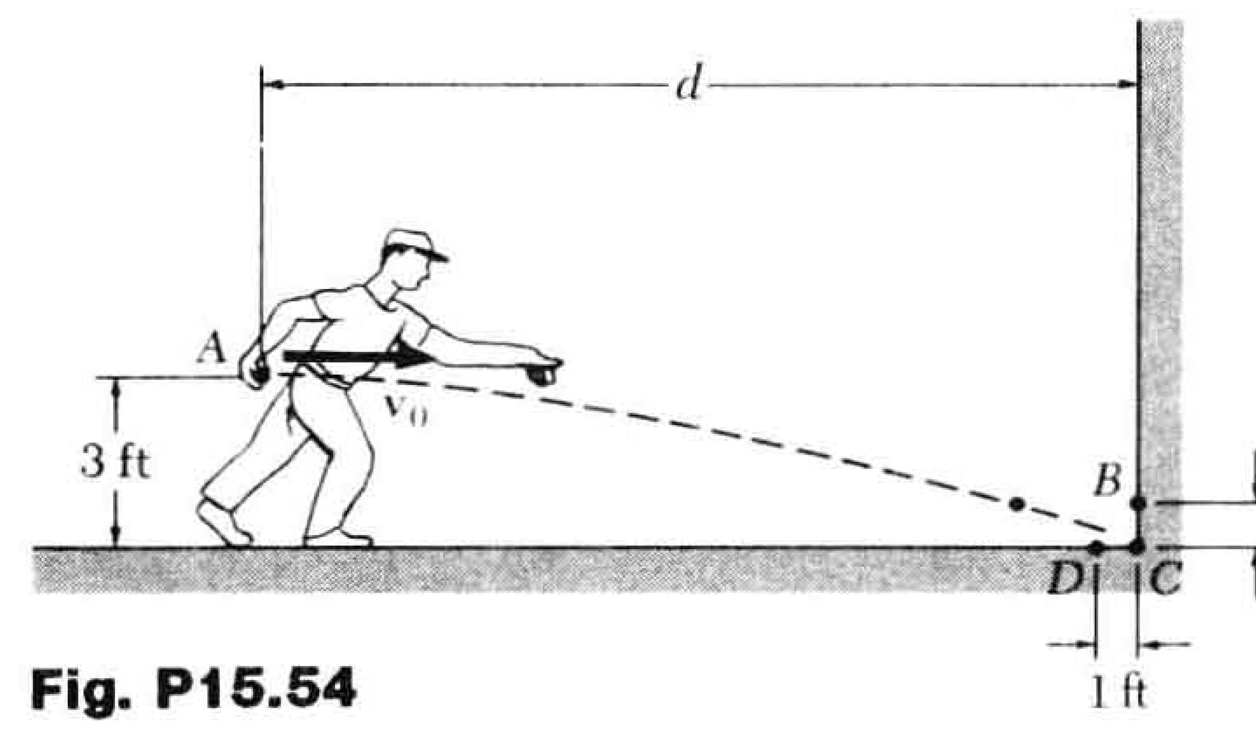

Fig. P15.54

11.55 Sand is discharged at *A* from a horizontal conveyor belt with an initial velocity $\mathbf{v}_0$. Determine the range of values of v_0 for which the sand will enter the vertical chute shown.

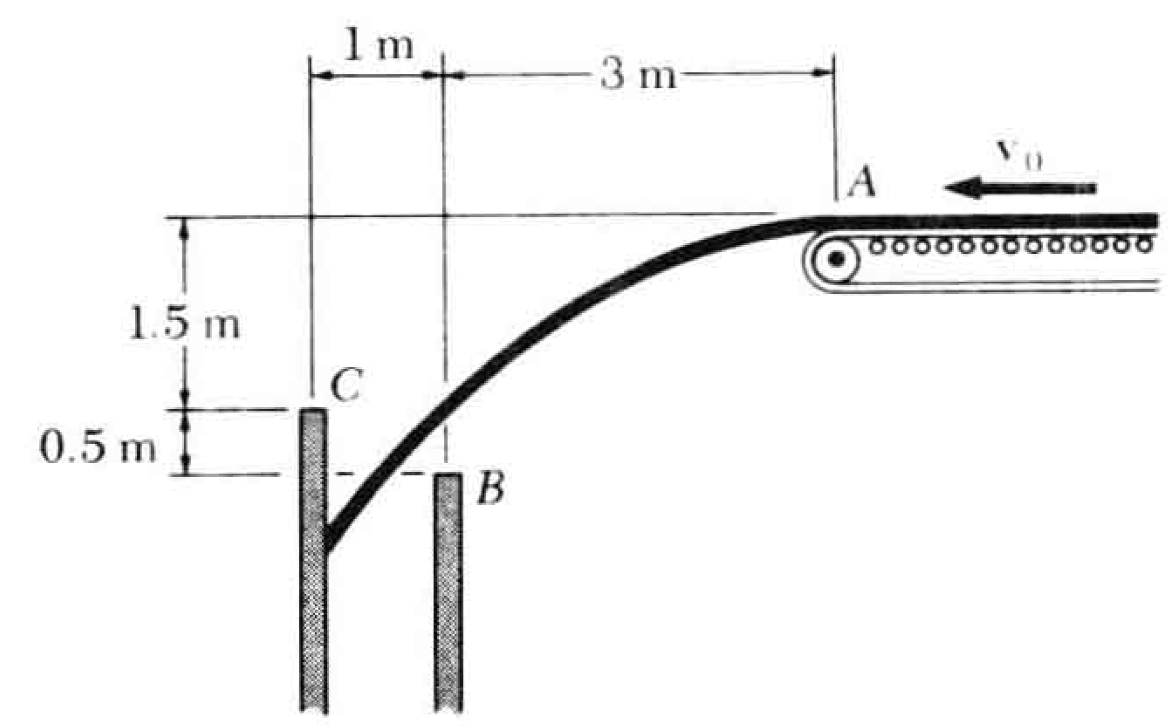

Fig. P11.55

11.56 A pump is located near the edge of the horizontal platform shown. The nozzle at *A* discharges water with an initial velocity of 25 ft/s at an angle of 50° with the vertical. Determine the range of values of the height *h* for which the water enters the opening *BC*.

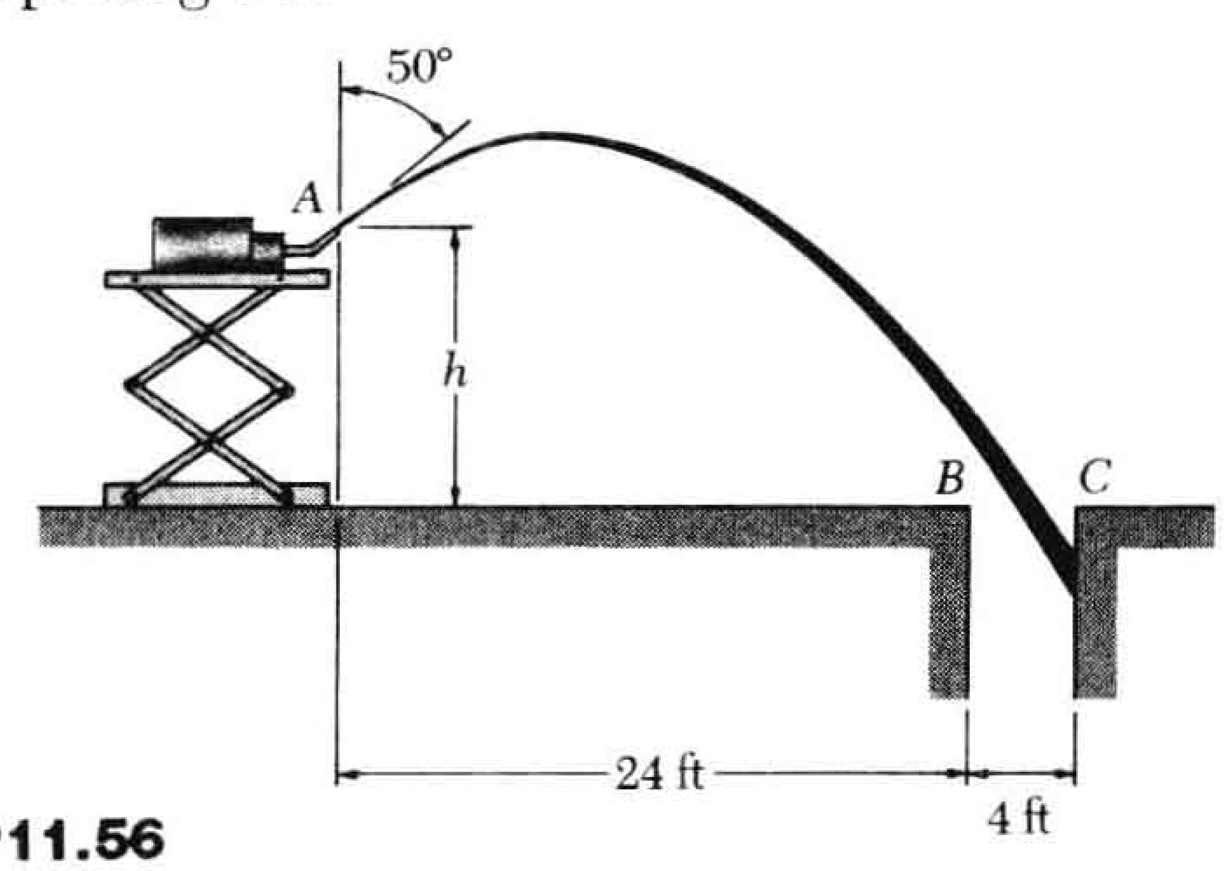

Fig. P11.56

11.57 An oscillating water sprinkler is operated at point *A* on an incline which forms an angle α with the horizontal. The sprinkler discharges water with an initial velocity $\mathbf{v}_0$ at an angle ϕ with the vertical which varies from $-\phi_0$ to $+\phi_0$. Knowing that $v_0 = 10$ m/s, $\phi_0 = 40°$, and $\alpha = 10°$, determine the horizontal distance between the sprinkler and points *B* and *C* which define the watered area.

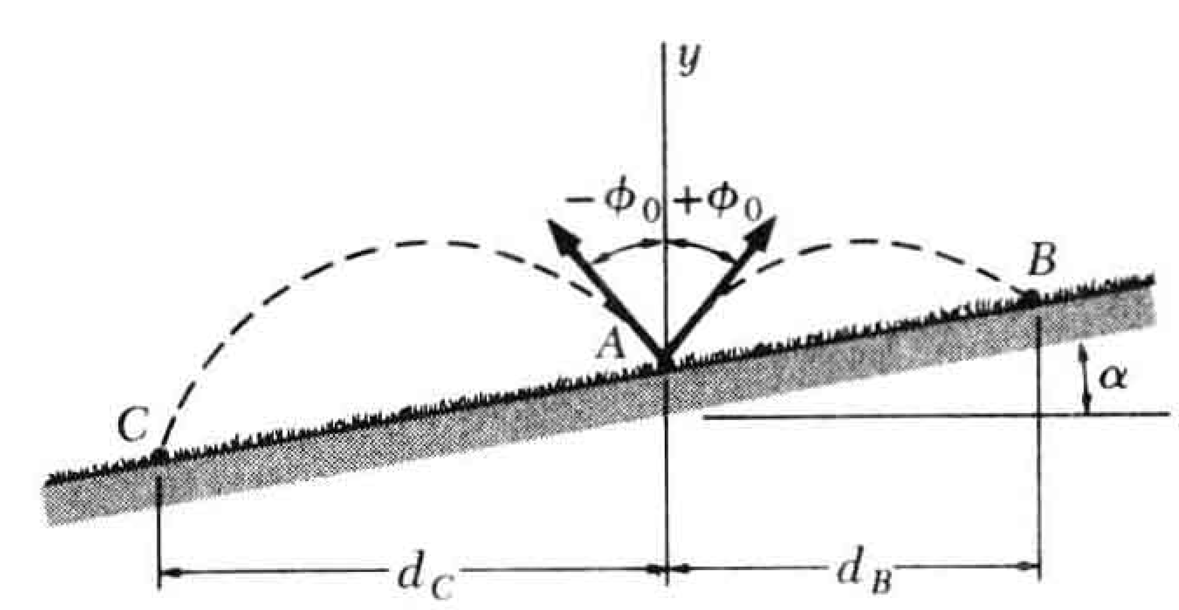

Fig. P11.57

11.58 A nozzle at *A* discharges water with an initial velocity of 12 m/s at an angle of 60° with the horizontal. Determine where the stream of water strikes the roof. Check that the stream will clear the edge of the roof.

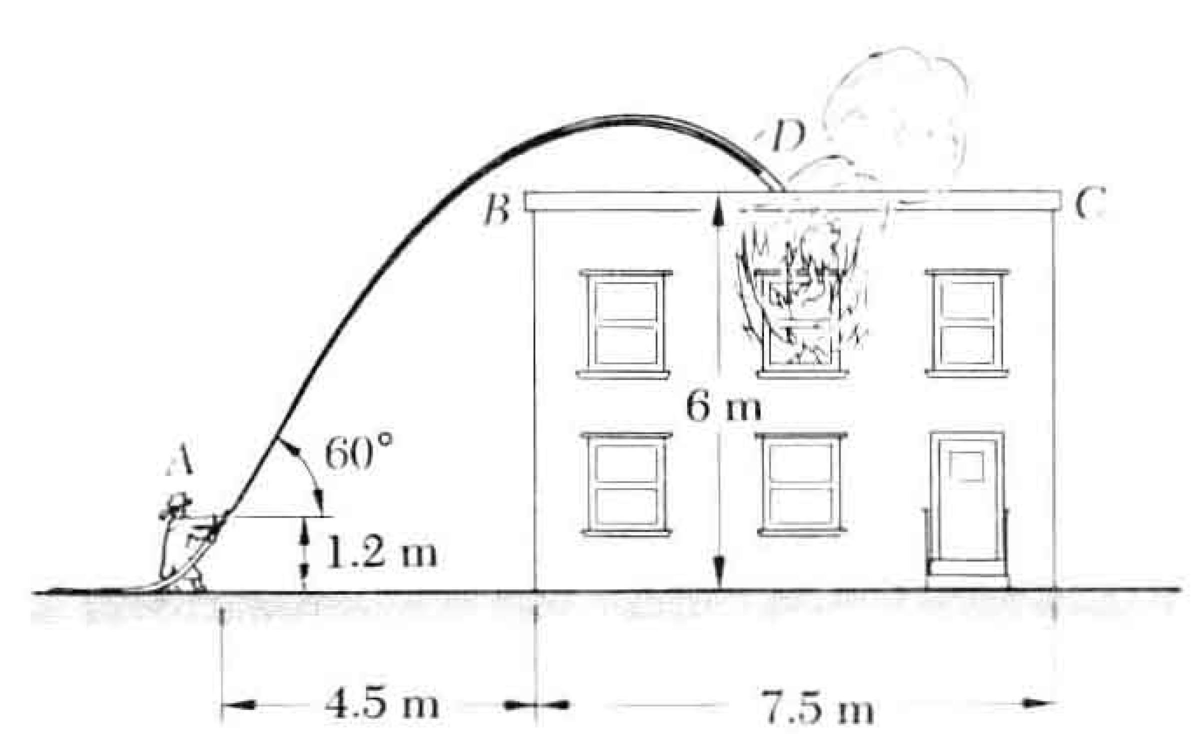

Fig. P11.58

11.59 A player throws a ball with an initial velocity $\mathbf{v}_0$ of 15 m/s from a point *A* located 1.5 m above the floor. Knowing that $h = 3$ m, determine the angle α for which the ball will strike the wall at point *B*.

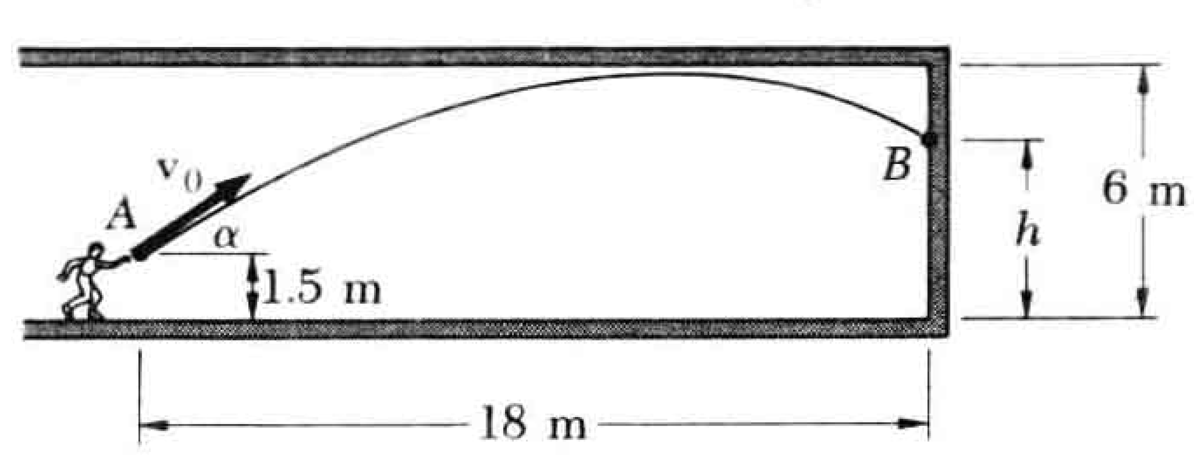

Fig. P11.59

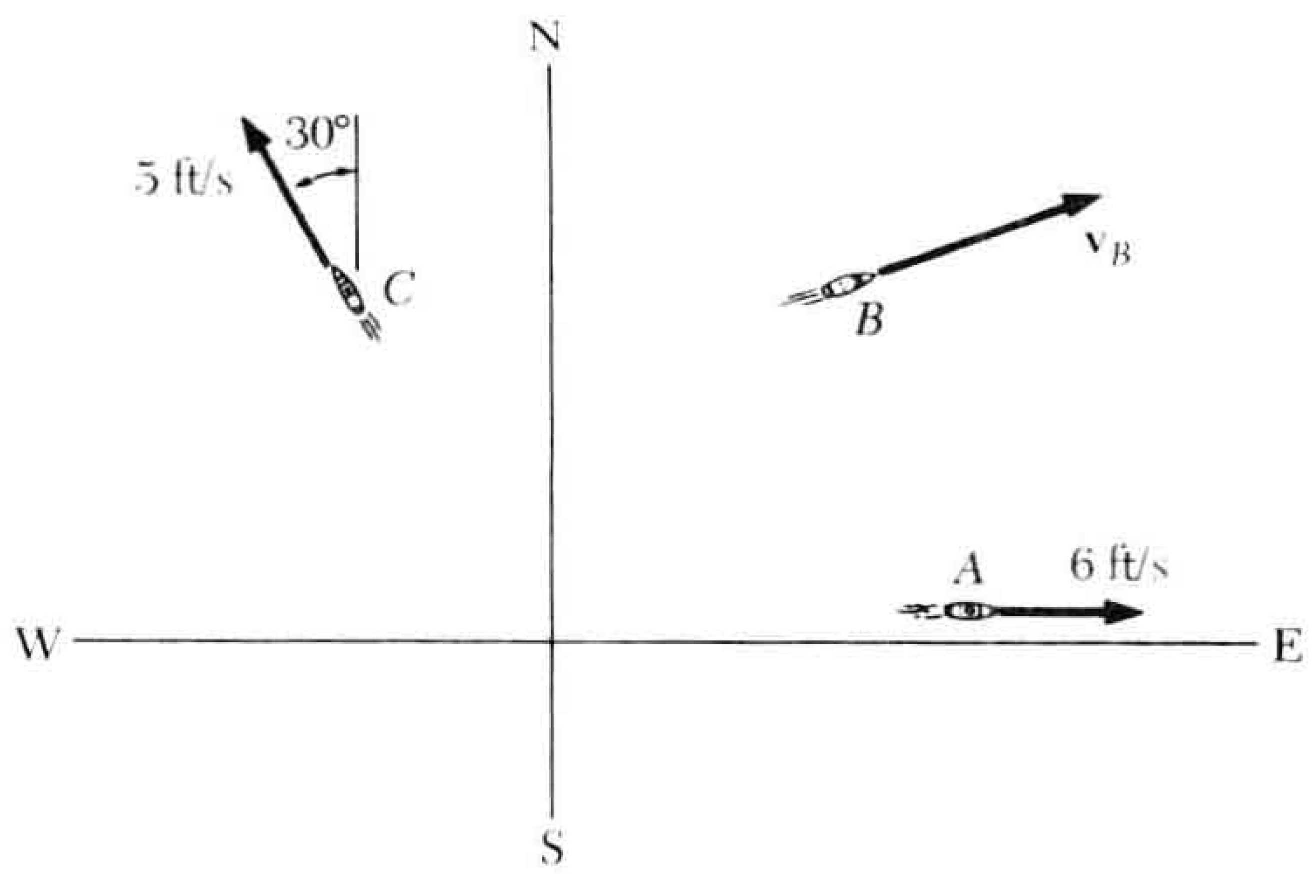

Fig. P11.60

11.60 The velocities of boats A and C are as shown and the relative velocity of boat B with respect to A is $\mathbf{v}_{B/A} = 4$ m/s ∠ 50°. Determine (a) $v_{A/C}$, (b) $v_{C/B}$, (c) the change in position of B with respect to C during a 10-s interval. Also show that for any motion, $\mathbf{v}_{B/A} + \mathbf{v}_{C/B} + \mathbf{v}_{A/C} = 0$.

11.61 Instruments in an airplane indicate that with respect to the air, the plane is moving north at a speed of 500 km/h. At the same time ground-based radar indicates that the plane is moving at a speed of 530 km/h in a direction 5° east of north. Determine the magnitude and direction of the velocity of the air.

11.62 Two airplanes A and B are flying at the same altitude; plane A is flying due east at a constant speed of 900 km/h, while plane B is flying southwest at a constant speed of 600 km/h. Determine the change in position of plane B relative to plane A, which takes place during a 2-min interval.

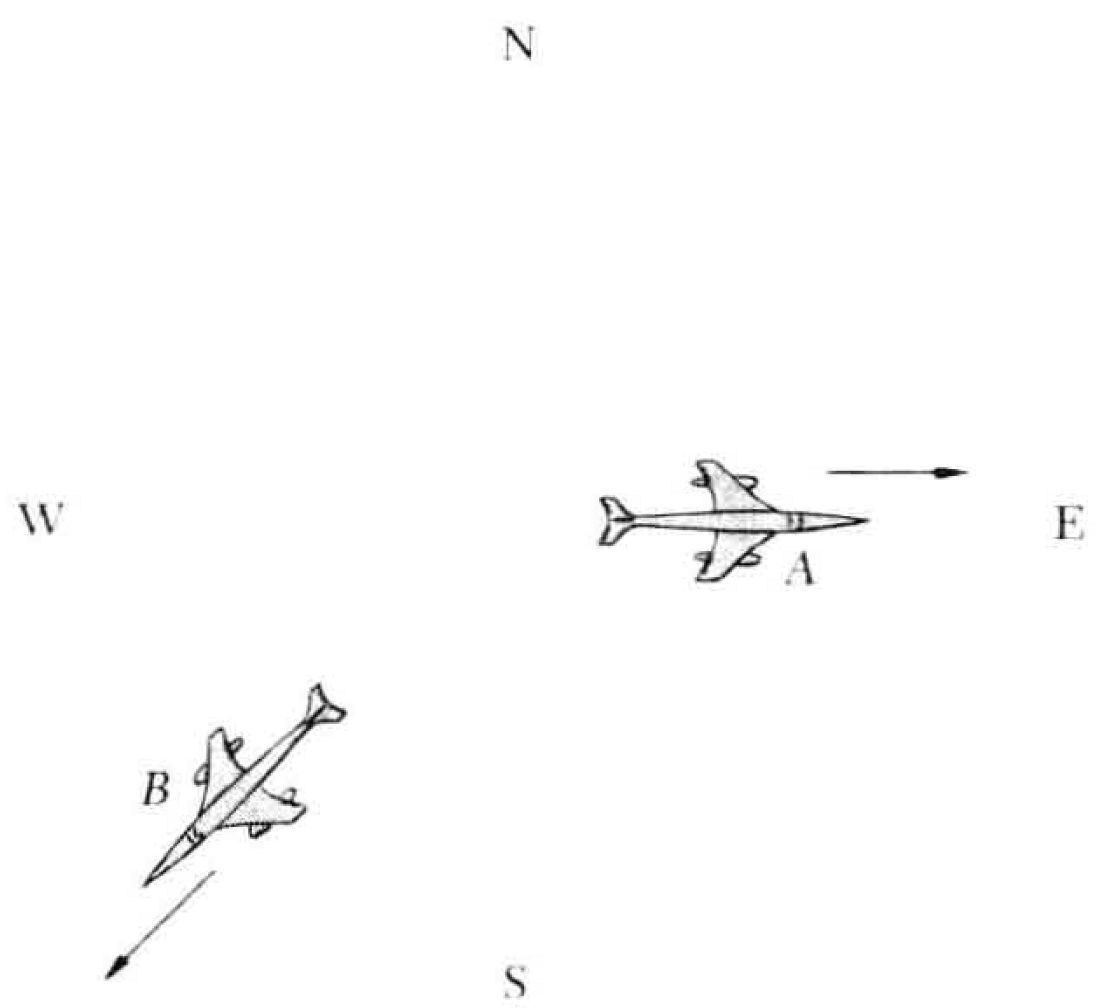

Fig. P11.62

11.63 Four seconds after automobile B passes through the intersection shown, automobile A passes through the same intersection. Knowing that the speed of each automobile is constant, determine (a) the relative velocity of B with respect to A, (b) the change in position of B with respect to A during a 3-s interval, (c) the distance between the two automobiles 2 s after A has passed through the intersection.

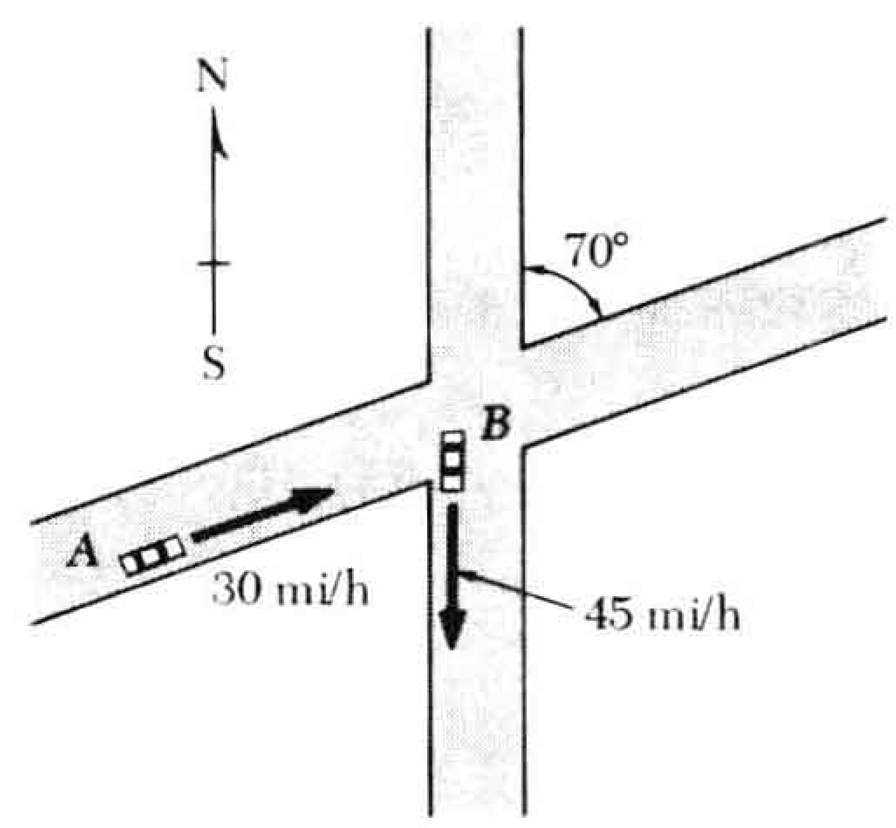

Fig. P11.63

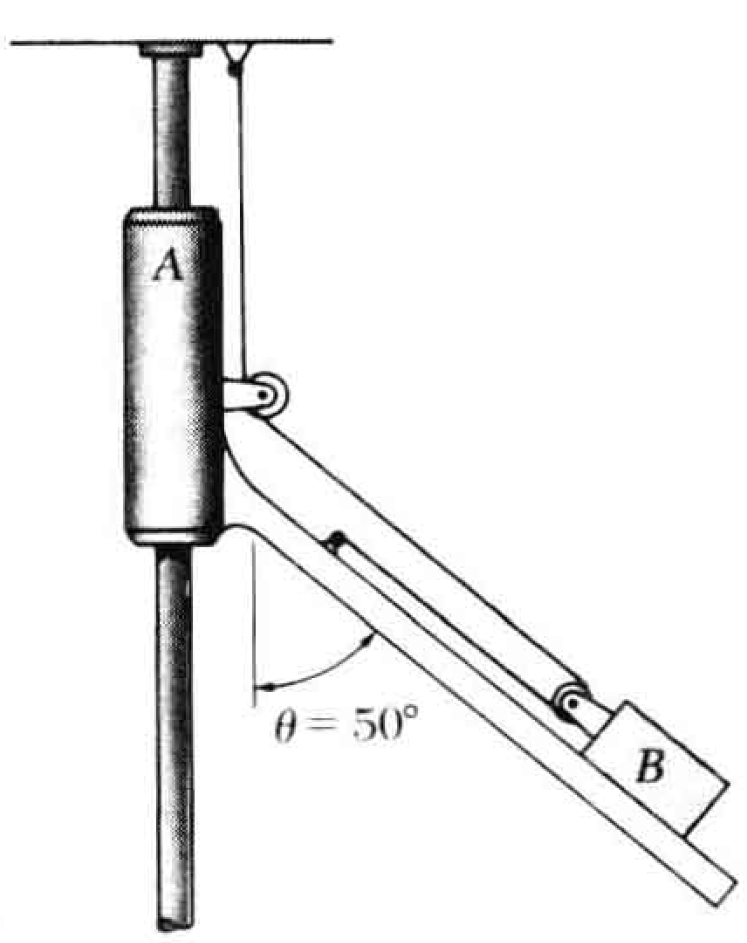

Fig. P11.64

11.64 Knowing that at the instant shown assembly A has a velocity of 16 in./s and an acceleration of 24 in./s^2 both directed downward, determine (a) the velocity of block B, (b) the acceleration of block B.

11.65 An antiaircraft gun fires a shell as a plane passes directly over the position of the gun, at an altitude of 6000 ft. The muzzle velocity of the shell is 1500 ft/s. Knowing that the plane is flying horizontally at 450 mi/h, determine (a) the required firing angle if the shell is to hit the plane, (b) the velocity and acceleration of the shell relative to the plane at the time of impact.

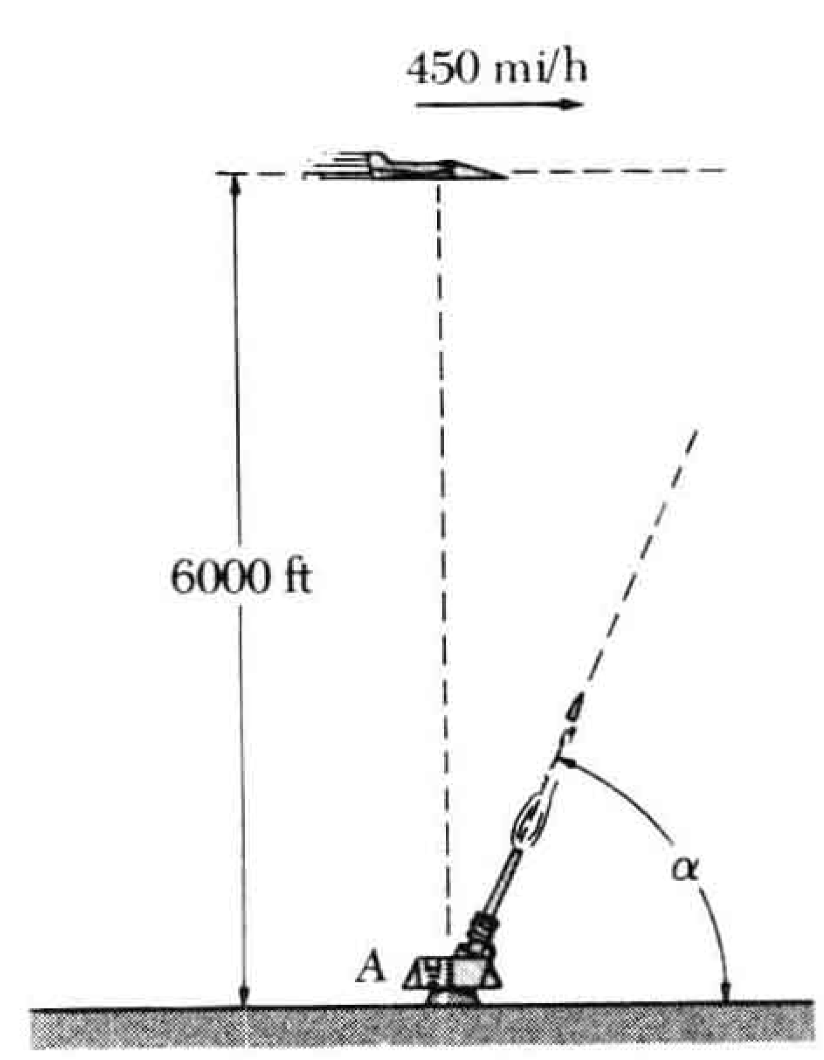

Fig. P11.65

11.66 What is the smallest radius which should be used for a highway curve if the normal component of the acceleration of a car traveling at 60 mi/h is not to exceed 2.5 ft/s^2?

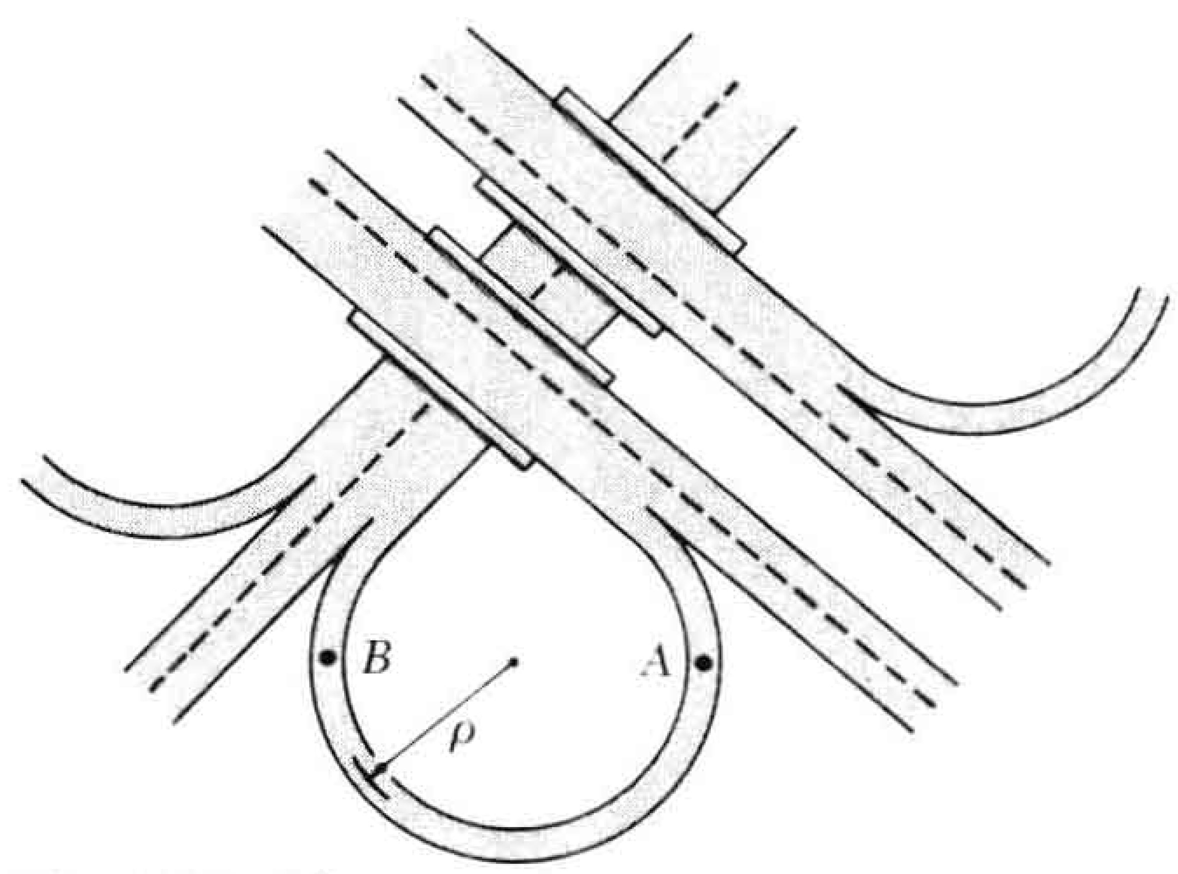

Fig. P11.67

11.67 A motorist drives along the circular exit ramp of a turnpike at the constant speed v_0. Knowing that the odometer indicates a distance of 0.6 km between point A where the automobile is going due south and B where it is going due north, determine the speed v_0 for which the normal component of the acceleration is 0.08g.

11.68 A computer tape moves over two drums at a constant speed v_0. Knowing that the normal component of the acceleration of the portion of tape in contact with drum B is 400 ft/s^2, determine (a) the speed v_0, (b) the normal component of the acceleration of the portion of tape in contact with drum A.

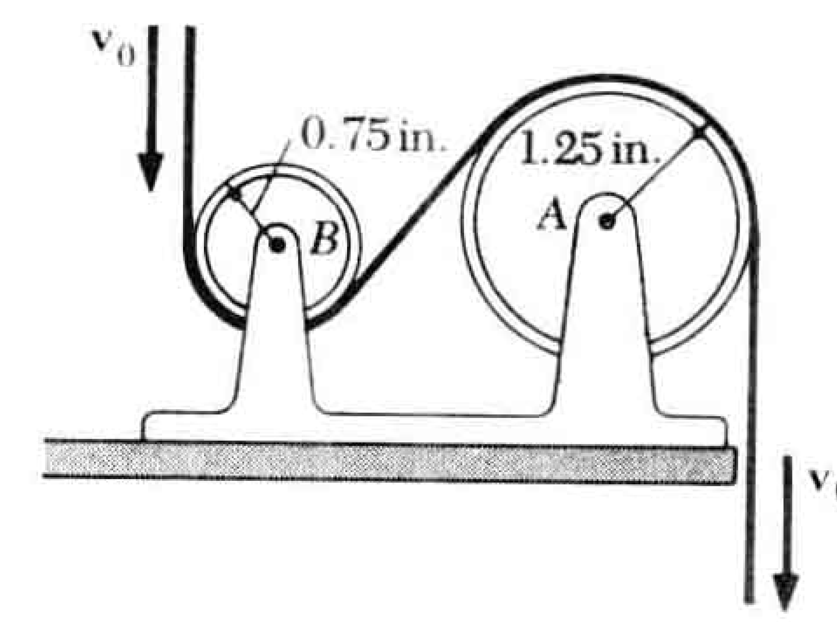

Fig. P11.68

11.69 A motorist is traveling on a curved portion of highway of radius 400 m at a speed of 90 km/h. The brakes are suddenly applied, causing the speed to decrease at a constant rate of 1.2 m/s^2. Determine the magnitude of the total acceleration of the automobile (a) immediately after the brakes have been applied, (b) 5 s later.

11.70 A bus starts from rest on a curve of 250-m radius and accelerates at the constant rate a_t = 0.6 m/s^2. Determine the distance and time that the bus will travel before the magnitude of its total acceleration is 0.75 m/s^2.

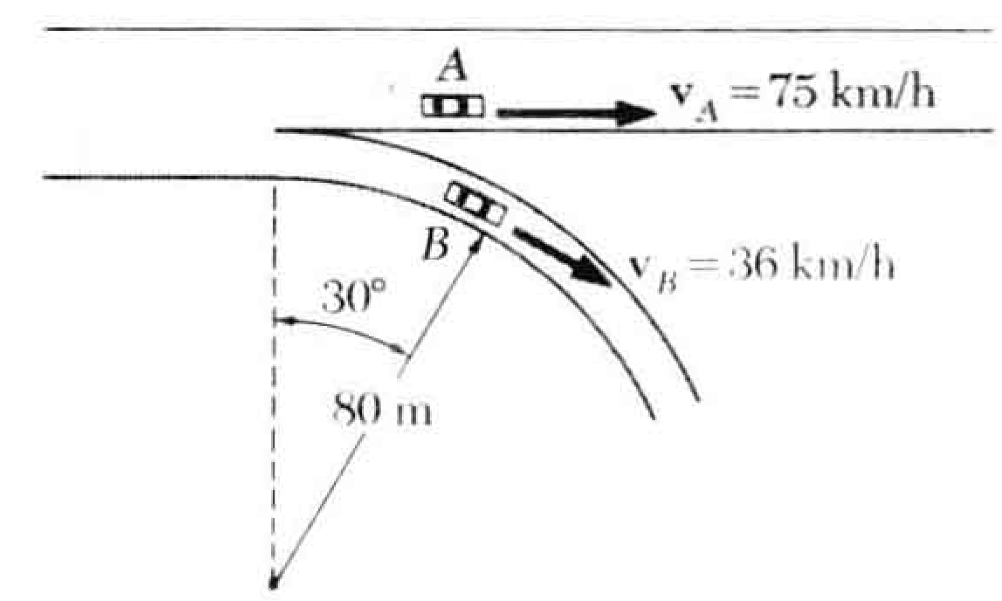

Fig. P11.72

11.71 A motorist decreases the speed of an automobile at a constant rate from 45 to 30 mi/h over a distance of 750 ft along a curve of 1500-ft radius. Determine the magnitude of the total acceleration of the automobile after it has traveled 500 ft along the curve.

11.72 Automobile A is traveling along a straight highway, while B is moving along a circular exit ramp of 80-m radius. The speed of A is being increased at the rate of 2 m/s^2 and the speed of B is being decreased at the rate of 1.2 m/s^2. For the position shown, determine (a) the velocity of A relative to B, (b) the acceleration of A relative to B.

11.73 A nozzle discharges a stream of water in the direction shown with an initial velocity of 25 ft/s. Determine the radius of curvature of the stream (a) as it leaves the nozzle, (b) at the maximum height of the stream.

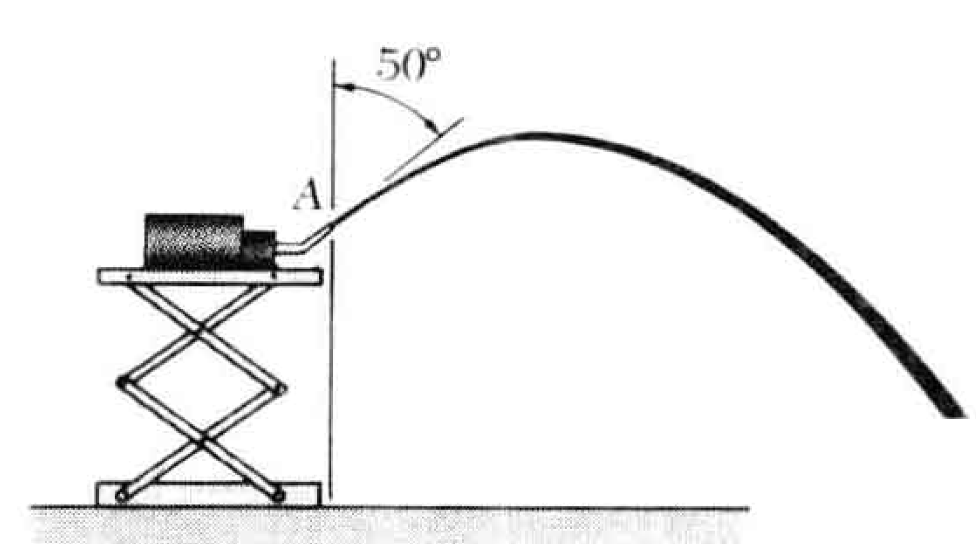

Fig. P11.73

11.74 A satellite will travel indefinitely in a circular orbit around the earth if the normal component of its acceleration is equal to $g(R/r)^2$, where g = 32.2 ft/s^2, R = radius of the earth = 3960 mi, and r = distance from the center of the earth to the satellite. Determine the height above the surface of the earth at which a satellite will travel indefinitely around the earth at a speed of 16,500 mi/h.

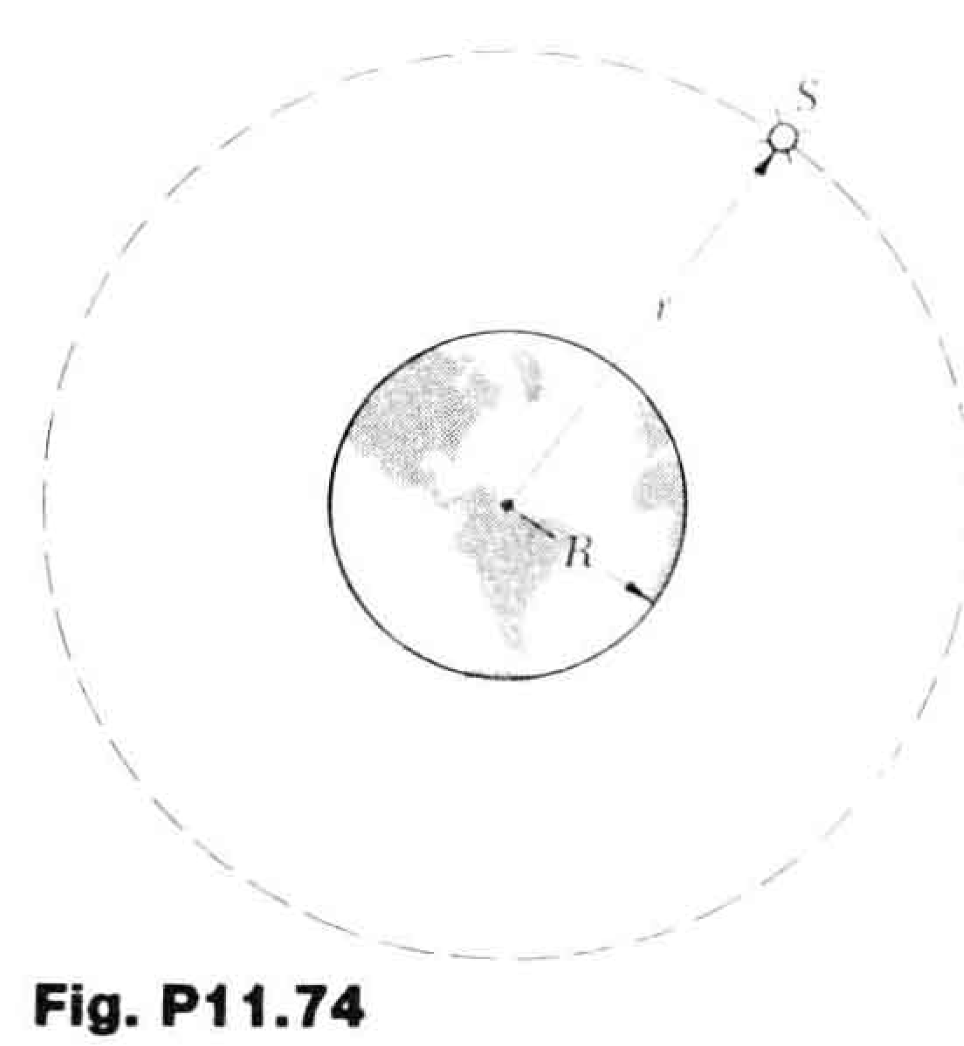

Fig. P11.74

11.75 The rotation of rod OA about O is defined by the relation $\theta = t^3 - 4t$, where θ is expressed in radians and t in seconds. Collar B slides along the rod in such a way that its distance from O is $r = 25t^3 - 50t^2$, where r is expressed in millimeters and t in seconds. When $t = 1$ s, determine (a) the velocity of the collar, (b) the total acceleration of the collar, (c) the acceleration of the collar relative to the rod.

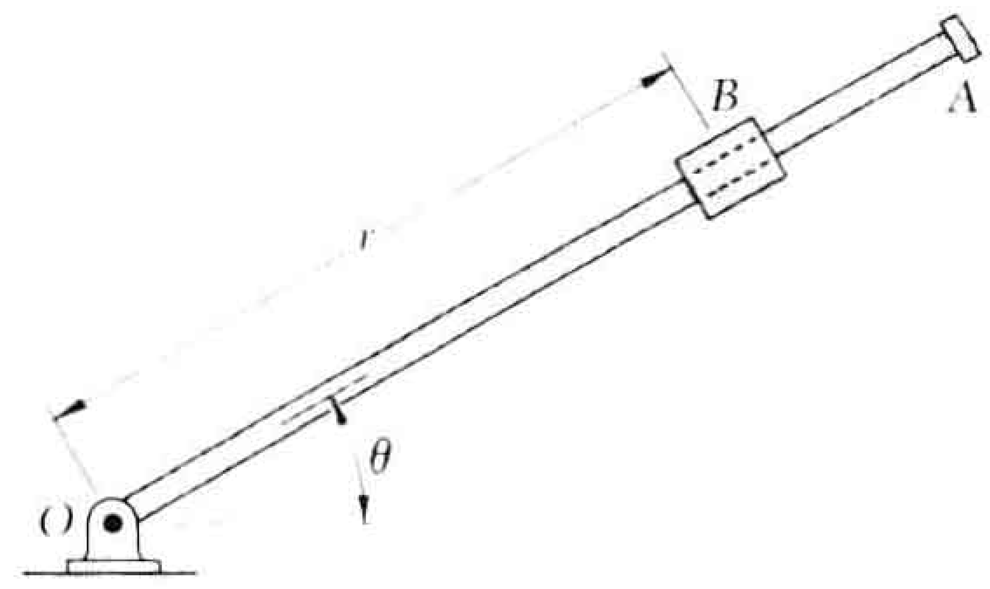

Fig. P11.75

11.76 A rocket is fired vertically from a launching pad at B. Its flight is tracked by radar from point A. Determine the velocity of the rocket in terms of b, θ, and $\dot{\theta}$.

11.77 The flight path of airplane B is a horizontal straight line and passes directly over a radar tracking station at A. Knowing that the airplane moves to the left with the constant velocity $\mathbf{v}_0$, determine $d\theta/dt$ in terms of v_0, h, and θ.

11.78 A test rocket is fired vertically from a launching pad at B. When the rocket is at P the angle of elevation is $\theta = 42.0°$, and 0.5 s later it is $\theta = 43.2°$. Knowing that $b = 3$ km, determine approximately the speed of the rocket during the 0.5-s interval.

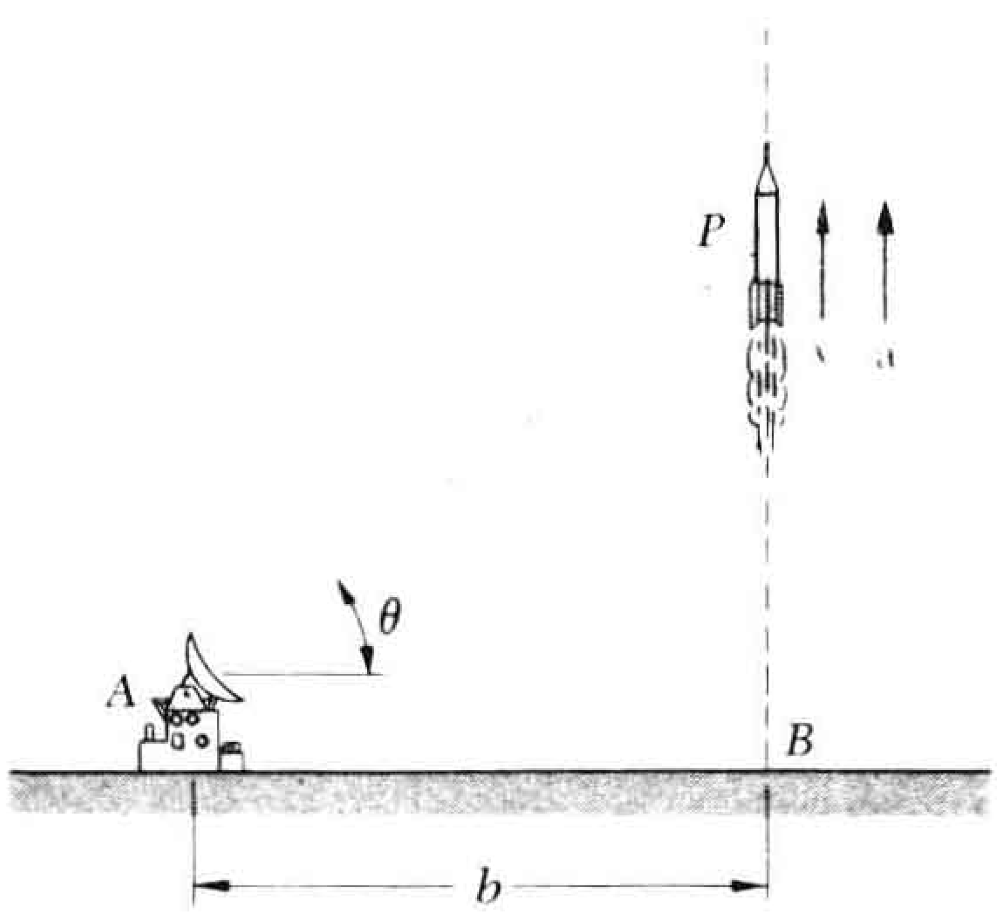

Fig. P11.76 and P11.78

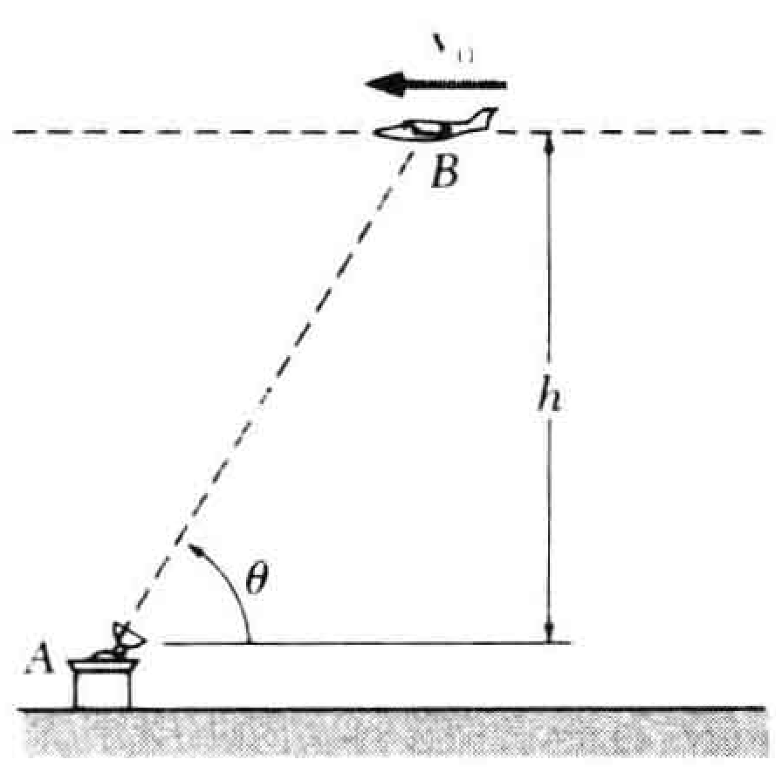

Fig. P11.77

11.79 An airplane passes over a radar tracking station at A and continues to fly due east. When the airplane is at P, the distance and angle of elevation of the plane are, respectively, $r = 11{,}200$ ft and $\theta = 26.5°$. Two seconds later the radar station sights the plane at $r = 12{,}300$ ft and $\theta = 23.3°$. Determine approximately the speed and the angle of dive α of the plane during the 2-s interval.

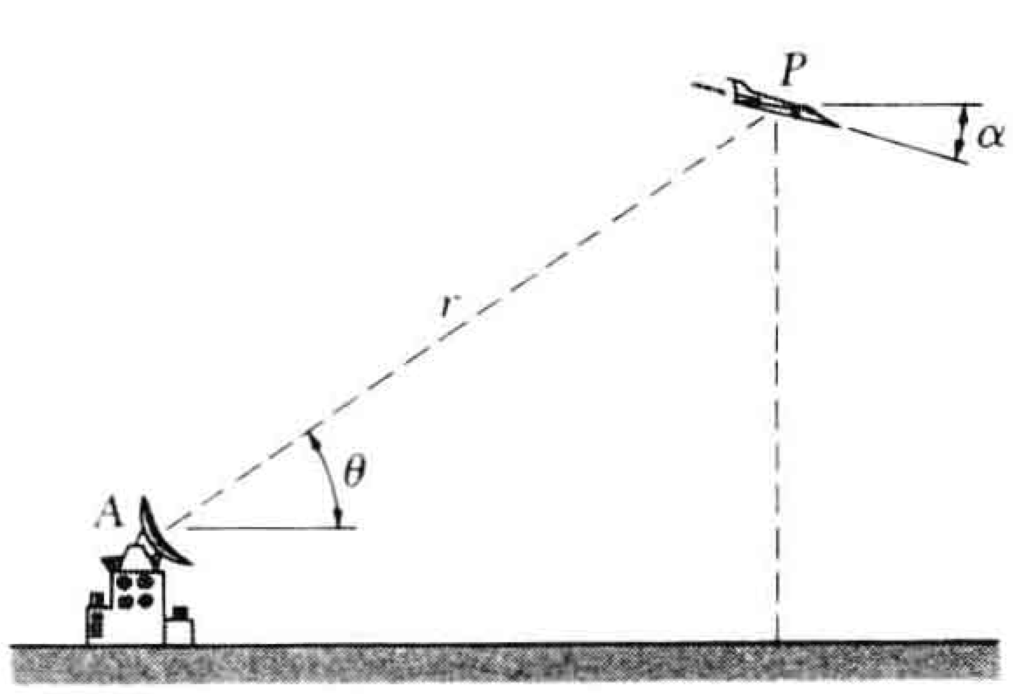

Fig. P11.79

11.80 As rod OA rotates, pin P moves along the parabola BCD. Knowing that the equation of the parabola is $r = 2b/(1 + \cos\theta)$ and that $\theta = kt$, determine the velocity and acceleration of P when (a) $\theta = 0$, (b) $\theta = 90°$.

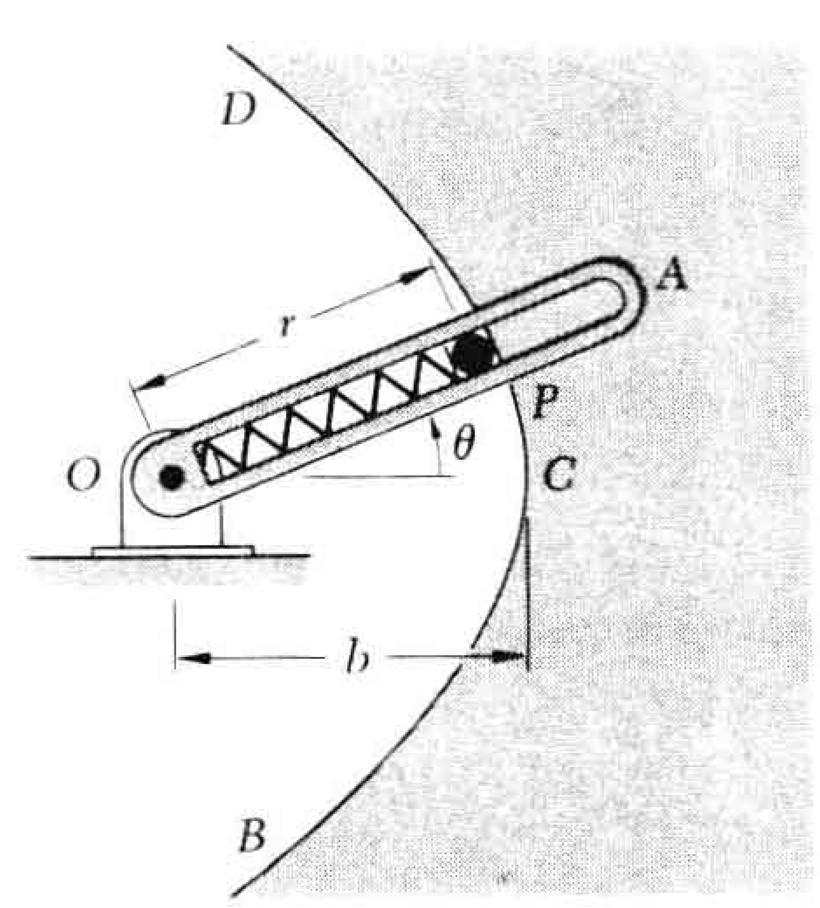

Fig. P11.80

11.81 The pin at B is free to slide along the circular slot DE and along the rotating rod OC. Assuming that the rod OC rotates at a constant rate $\dot{\theta}$, (a) show that the acceleration of pin B is of constant magnitude, (b) determine the direction of the acceleration of pin B.

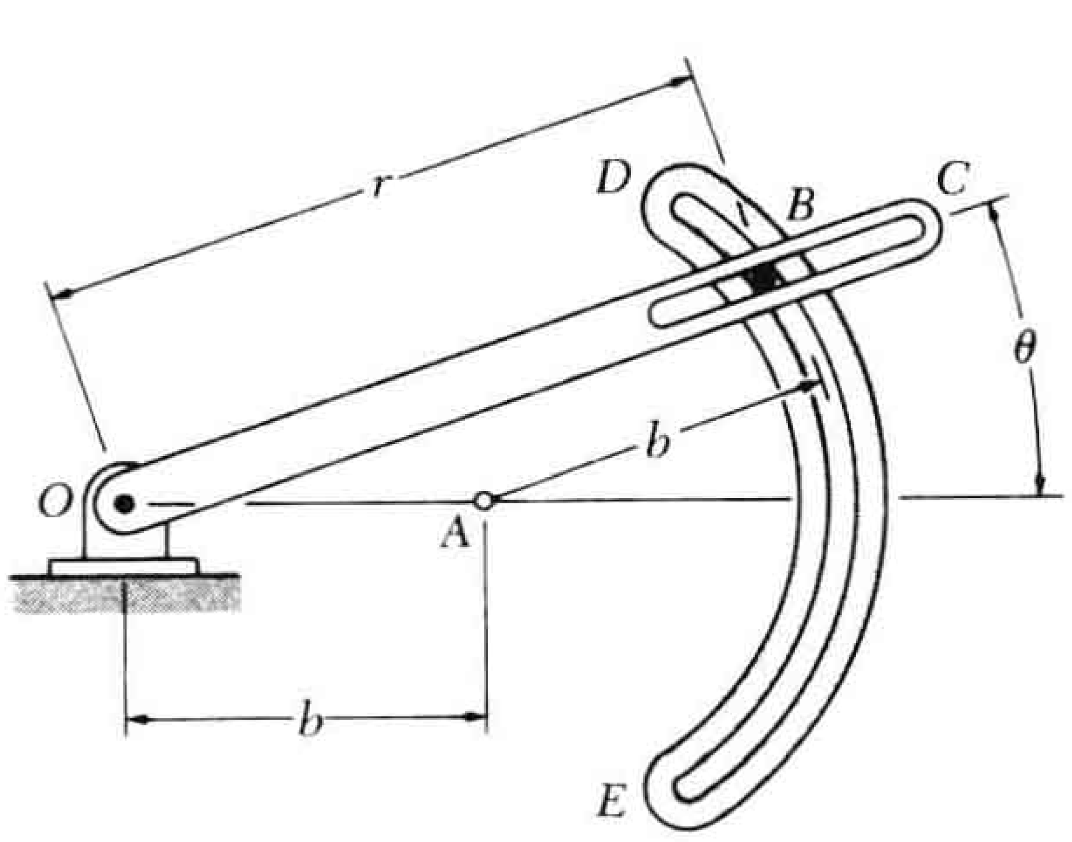

Fig. P11.81

11.C1 The magnitude in m/s^2 of the deceleration due to air resistance of the nose cone of a small experimental rocket is known to be $0.0005v^2$, where v is expressed in m/s. The nose cone is projected vertically from the ground with an initial velocity of 100 m/s. Derive expressions for the velocity of the cone as a function of height as the cone moves up to its maximum height and then back down to the ground. Plot the velocity as a function of the height. [Hint: The total acceleration of the cone as it moves up is $-(g + 0.0005v^2)$, and as it moves down is $-(g - 0.0005v^2)$, where $g = 9.81\ m/s^2$.]

11.C2 A projectile enters a resisting medium at $x = 0$ with an initial velocity $v_0 = 900$ ft/s. The velocity of the projectile is defined by the relation $v = v_0 - kx$, where v is expressed in ft/s, x in feet, and $k = 2700\ s^{-1}$. Derive expressions for the position, velocity, and acceleration of the projectile as functions of time. Plot the position, velocity, and acceleration of the projectile as functions of time from the time the projectile enters the medium.

11.C3 The motion of a particle is defined by the equations $x = 1.5t^2 - 6t$ and $y = 6t^2 - 2t^3$, where x and y are expressed in inches and t in seconds. Derive expressions for the magnitudes of the velocity and acceleration of the particle as a function of time.

(d) Plot the trajectory of the particle.
(e) Plot the rectangular components of the velocity v_x and v_y and the total velocity v as a function of time for $t = 0$ until $t = 20$ s.
(f) Plot the rectangular components of the acceleration a_x and a_y and the total acceleration a as a function of time for $t = 0$ until $t = 20$ s.

11.C4 The rotation of rod OA about O is defined by the relation $\theta = t^3 + 4t$, where θ is expressed in radians and t in seconds. Collar B slides along the rod in such a way that its distance from O is $r = 25t^3 + 50t^2$, where r is expressed in millimeters and t in seconds. Plot the position of the particle for one revolution of the rod starting from $t = 0$. Derive expressions for the radial and transverse components of the velocity and acceleration as a function of time. Plot the radial and transverse components of the velocity and the magnitude of the velocity as functions of time for one revolution of the rod. Plot the radial and transverse components of the acceleration and the magnitude of the acceleration as functions of time for one revolution of the rod.

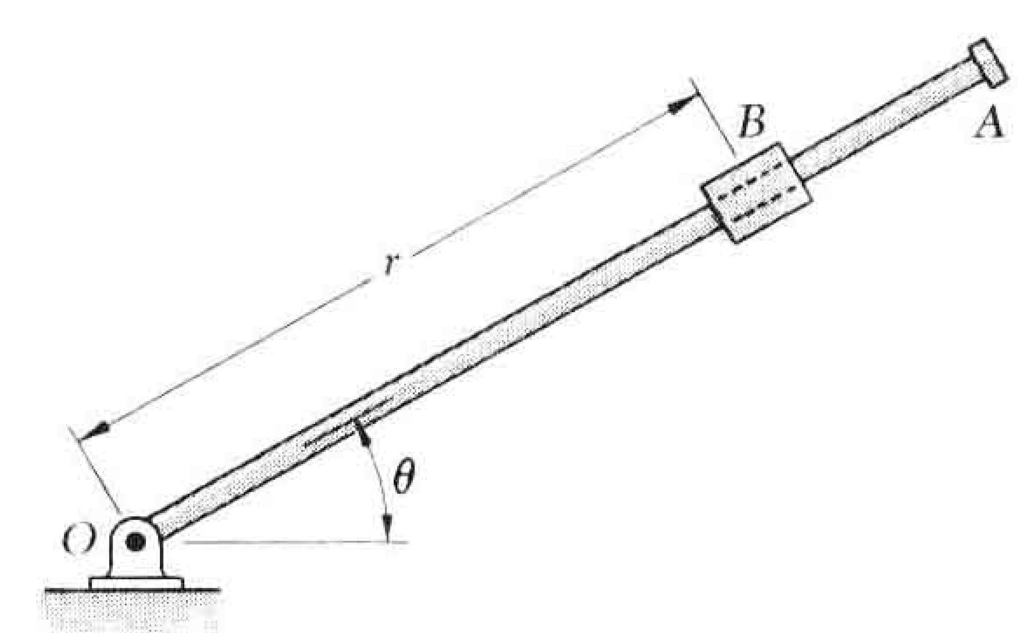

Fig. P11.C4

11.C5 The motion of a particle along an elliptical path is defined by the relations $r = 35/(1 - 0.75\cos \pi t)$ and $\theta = \pi t$, where r is expressed in millimeters and θ in radians. Plot the position of the particle for $\theta = 0$ to $\theta = 2\pi$. Derive expressions for the radial and transverse components of the velocity and acceleration as functions of time. Plot the radial and transverse components of the velocity and the magnitude of the velocity as functions of time for $t = 0$ to $t = 2$ s. Plot the radial and transverse components of the acceleration and the magnitude of the acceleration as functions of time for $t = 0$ to $t = 2$ s.

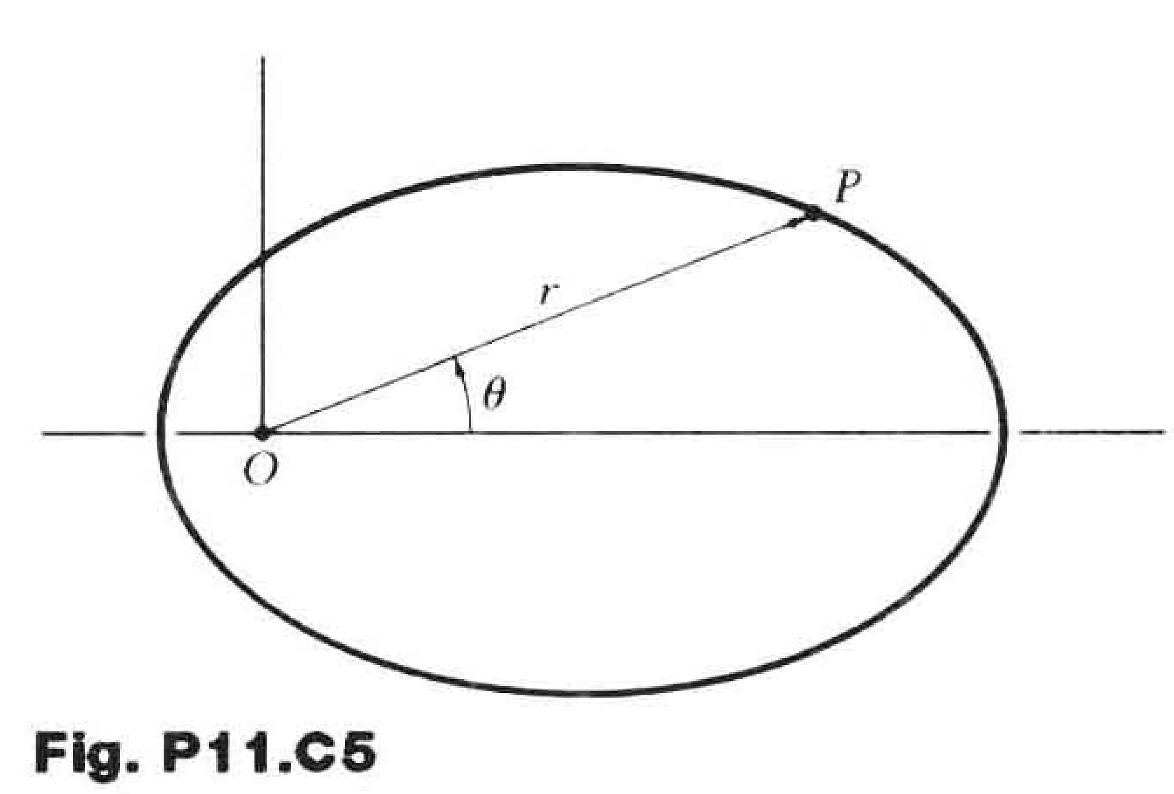

Fig. P11.C5

CHAPTER 12
KINEMATICS OF PARTICLES: NEWTON'S SECOND LAW

SECTIONS 12.1 to 12.6

12.1 A motorist traveling at a speed of 90 km/h suddenly applies the brakes and comes to a stop after skidding 50 m. Determine (*a*) the time required for the car to stop, (*b*) the coefficient of friction between the tires and the pavement.

12.2 A car has been traveling up a long 2 percent grade at a constant speed of 55 mi/h. If the driver does not change the setting of the throttle or shift gears as the car reaches the top of the hill, what will be the acceleration of the car as it starts moving down the 3 percent grade?

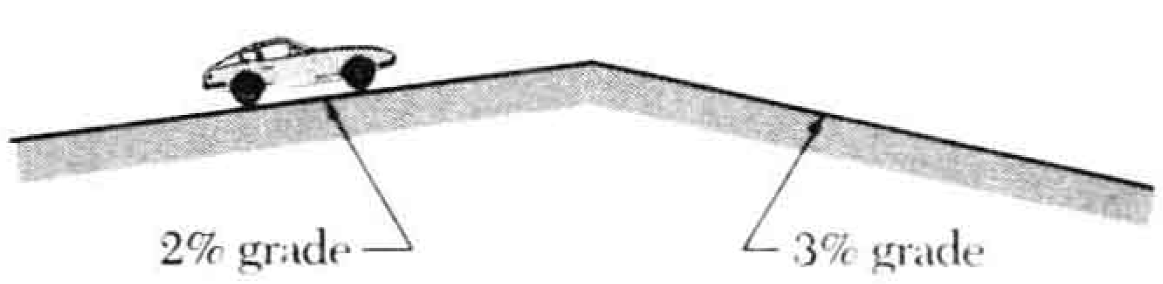

Fig. P12.2

12.3 The two blocks shown are originally at rest. Neglecting the masses of the pulleys and the effect of friction in the pulleys and between block *A* and the incline, determine (*a*) the acceleration of each block, (*b*) the tension in the cable.

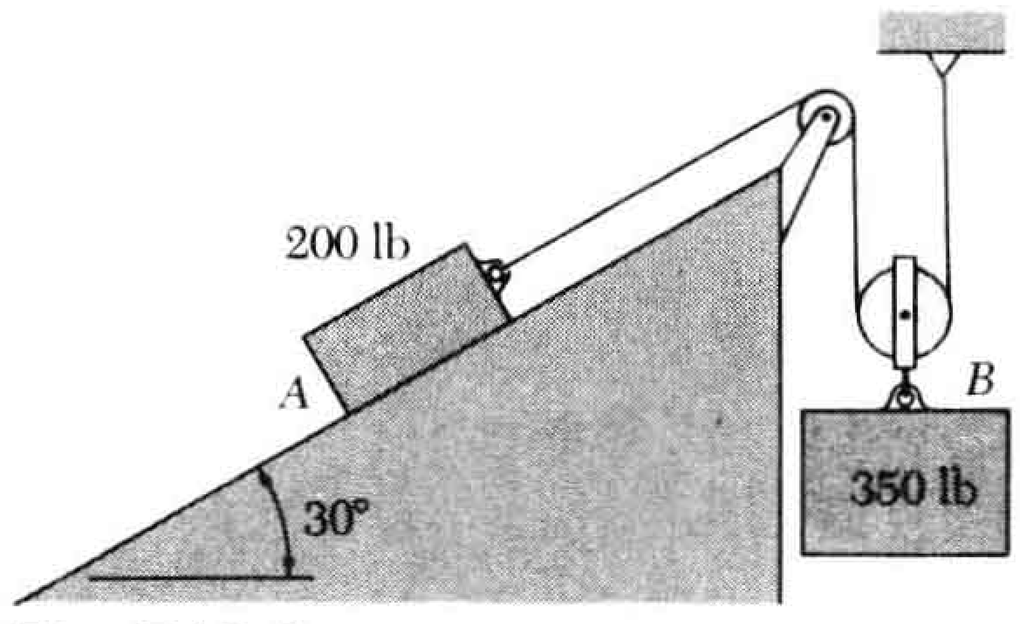

Fig. P12.3

12.4 A 1050-kg trailer is hitched to a 1200-kg car. The car and trailer are traveling at 90 km/h when the driver applies the brakes on both the car and the trailer. Knowing that the braking forces exerted on the car and the trailer are 4500 N and 3600 N, respectively, determine (*a*) the deceleration of the car and trailer, (*b*) the horizontal component of the force exerted by the trailer hitch on the car.

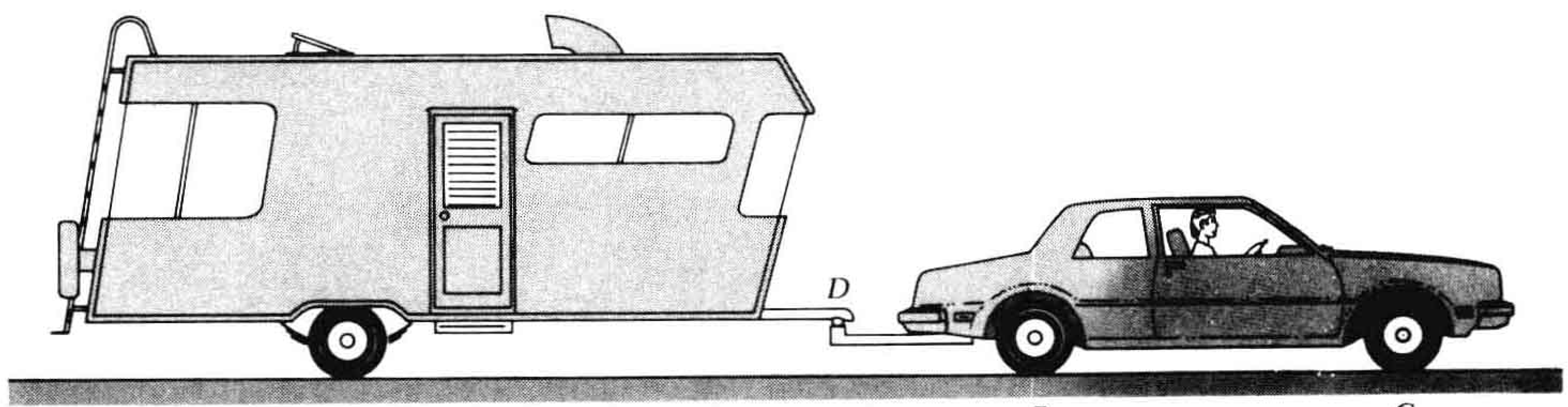

Fig. P12.4