CHAPTER IV

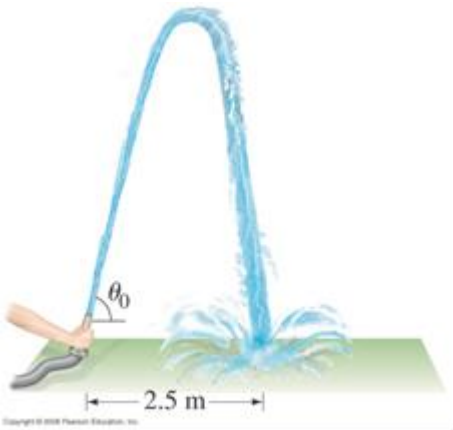
MOTION IN TWO AND THREE DIMENSIONS

PROBLEM SET

1) ***The position of a particular particle as a function of time is given by $\vec{\mathbf{r}} = \left(9.60\,t\ \hat{\mathbf{i}} + 8.85\,\hat{\mathbf{j}} - 1.00\,t^2\ \hat{\mathbf{k}}\right)$ m. Determine the particle's velocity and acceleration as a function of time. **[Answer: $\vec{v} = (\mathbf{9.60\hat{i} - 2.00}t\hat{\mathbf{k}})m/s$, $\vec{\mathbf{a}} = \mathbf{-2.00}\hat{k}\ m/s^2$]**

2) (a) A skier is accelerating down a 30.0° hill at 1.80 m/s^2 (Fig. 3–39). What is the vertical component of her acceleration? (b) How long will it take her to reach the bottom of the hill, assuming she starts from rest and accelerates uniformly, if the elevation change is 325 m?
[Answer: a) 0.900 m/s^2, b) 26.9 s]

3) A fire hose held near the ground shoots water at a speed of 6.5 m/s. At what angle(s) should the nozzle point in order that the water land 2.5 m away (Fig. 3–40)? Why are there two different angles? Sketch the two trajectories.**[Answer: $\mathbf{18^0}, \mathbf{72^0}$ There are two angles because each angle gives the same range. If one angle is $\theta = 45° + \delta$, then $\theta = 45° - \delta$ is also a solution.]**



4) A baseball is hit with a speed of 27.0 m s at an angle of 45.0°. It lands on the flat roof of a 13.0-m-tall nearby building. If the ball was hit when it was 1.0 m above the ground, what horizontal distance does it travel before it lands on the building? **[Answer: 59.3 m]**

5) Extreme-sports enthusiasts have been known to jump off the top of El Capitan, a sheer granite cliff of height 910 m in Yosemite National Park. Assume a jumper runs horizontally off the top of El Capitan with speed 5.0 m/s and enjoys a freefall until she is 150 m above the valley floor, at which time she opens her parachute (Fig. 3–41). (a) How long is the jumper in freefall? Ignore air resistance. (b) It is important to be as far away from the cliff as possible before opening the parachute. How far from the cliff is this jumper when she opens her chute?
[Answer: a)12 s, b) 62 m]

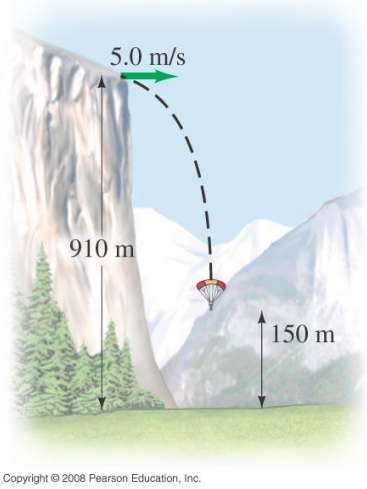


Fig. 3–41

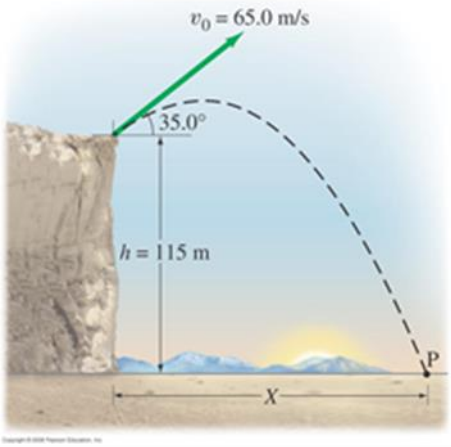
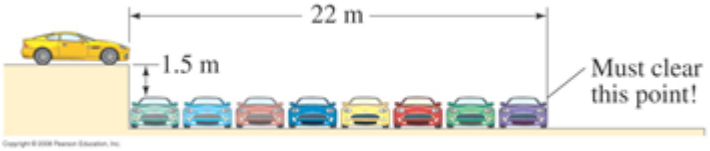


Fig. 3–44

6) *** A projectile is shot from the edge of a cliff 115 m above ground level with an initial speed of 65.0 m/s at an angle of 35.0° with the horizontal, as shown in Fig. 3–44. (a) Determine the time taken by the projectile to hit point P at ground level. (b) Determine the distance X of point P from the base of the vertical cliff. At the instant just before the projectile hits point P, find (c) the horizontal and the vertical components of its velocity, (d) the magnitude of the velocity, and (e) the angle made by the velocity vector with the horizontal. (f) Find the maximum height above the cliff top reached by the projectile.**[Answer: a) 9.96 s, b)531 m, c)$v_x = 53.2\ m/s$, $v_x = -60.4\ m/s$, d) $v = 80.5\ m/s$, e) 48.6^0 below the horizontal, f)70.9 m]**

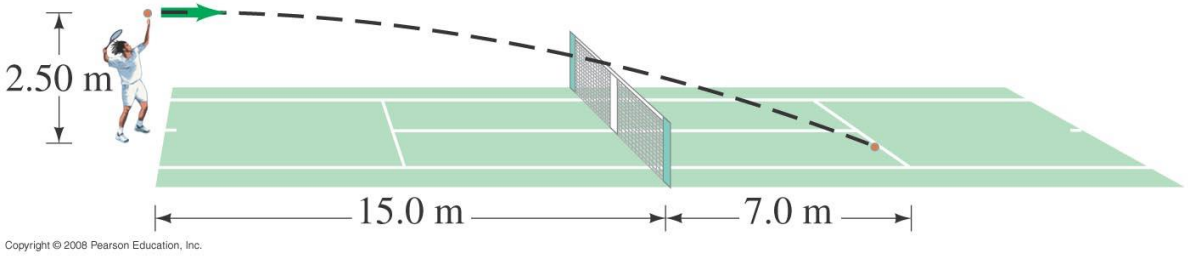
7) A stunt driver wants to make his car jump over 8 cars parked side by side below a horizontal ramp (Fig. 3–46). (a) With what minimum speed must he drive off the horizontal ramp? The vertical height of the ramp is 1.5 m above the cars and the horizontal distance he must clear is 22 m. (b) If the ramp is now tilted upward, so that "takeoff angle" is 7.0° above the horizontal, what is the new minimum speed? **[Answer: a) 40 m/s, b)24 m/s]**



8) An Olympic long jumper is capable of jumping 8.0 m. Assuming his horizontal speed is 9.1 m/s as he leaves the ground, how long is he in the air and how high does he go? Assume that he lands standing upright—that is, the same way he left the ground. **[Answer: 0.88 s, 0.95 m]**

9) At serve, a tennis player aims to hit the ball horizontally. **What** minimum **speed** is required for the ball to clear the 0.90-m-high net about 15.0 m from the server if the ball is "launched" from a height of 2.50 m? **Where** will the ball land if it just clears the net (and will it be "good" in the sense that it lands within 7.0 m of the net)? **How long** will it be in the air? See Fig. 3–58.

[Answer: 26.3 m/s, 18.8 m, 0.714 s]



10) *** A basketball is shot from an initial height of 2.4 m (Fig. 3–62) with an initial speed $v_0 = 12\ m/s$ directed at an angle $\theta_0 = 35^0$ above the horizontal. (*a*) How far from the basket was the player if he made a basket? (*b*) At what angle to the horizontal did the ball enter the basket?
[Answer: a) 13 m, b) -31^0]