Chapter 4 Even Problem Solutions

18. The stuntman must cover 4.5m horizontally by the time he falls 1.9m. The problem says that he runs off the roof so we assume he runs off horizontally. To solve for how long it will take for the stuntman to fall 1.9m, we can use:

$$1.9m = \frac{1}{2} * (9.8\frac{m}{s^2}) * t^2 \tag{1}$$

$$\Rightarrow t = \sqrt{\frac{2 * 1.9}{9.8}} s = .62s \tag{2}$$

Thus, to cover 4.5m in the time of .62s, the stuntman must run at:

$$\boxed{v = \frac{4.5m}{.62s} = 7.3\frac{m}{s}} \tag{3}$$

22. This is very similar to problem 18. We have:

$$h = \frac{1}{2} g t^2 \tag{4}$$

$$\Rightarrow t = \sqrt{\frac{2h}{g}} \tag{5}$$

Therefore, the distance covered is:

$$d = v_0 t = v_0 \sqrt{\frac{2h}{g}} \tag{6}$$

To check our formula, one should first check that it is dimensionally correct. We have units of distance on both the left and right hand sides. Additionally, we expect that as height and velocity increase, the projectile would go a farther distance, and as the gravitational acceleration increases, the projectile would go a shorter distance just as our equation suggests.

26. We are asked to find the travel time for a projectile shot at $50\frac{m}{s}$ and an angle of 30° and 60°. To do this problem, we only need to consider the vertical direction since the projectile, by definition, stops after it hits the ground. For the first case (30°):

$$v_{y,0} = 50 \sin(30°) = 25\frac{m}{s} \tag{7}$$

Therefore:

$$y(t) = v_{y,0} t - \frac{1}{2} g t^2 = 0 \tag{8}$$

$$\Rightarrow \boxed{t = \frac{2 v_{y,0}}{g} = \frac{2 * 25}{9.8} s = 5.1s} \tag{9}$$

We do the exactly analogous thing with the second case (60°):

$$v_{y,0} = 50\sin(60^\circ) = 43.3\frac{m}{s} \tag{10}$$

$$\Rightarrow \boxed{t = \frac{2v_{y,0}}{g} = \frac{2 * 43.3}{9.8}s = 8.8s} \tag{11}$$

Therefore, the projectile fired at a higher angle takes a longer time to get to its desitination as one would expect.

34. To do this problem, we first have to do some geometry to figure out the height of the house. We are given that the house is 6m wide, and the roof makes a 45 degree angle with the horizontal, therefore the roof has height 3 meters due to the properties of a 45-45-90 degree triangle. Therefore, we must throw the ball a total of 16 meters across, and it must clear an obstacle 6 meters high (remembering that the ball starts and stops 1 meter off the ground). It helps to draw a figure yourself. To do this problem, we consider the two directions separately. The two equations for the displacement are:

$$x(t) = v_{0,x}t \tag{12}$$

$$y(t) = v_{0,y}t - \frac{1}{2}gt^2 \tag{13}$$

Note that we have set the origin of our coordinate system at 1 meter off the ground and 5 meters to the left of the house. By the time the ball moves 8 meters horizontally, it must be 6 meters off the ground, or 5 meters above the x-axis in our coordinate system. Mathimatically:

$$8 = x(t) = v_{0,x}t \tag{14}$$

$$\Rightarrow t = \frac{8}{v_{0,x}} \tag{15}$$

$$5 = y(t) = v_{0,y} * \frac{8}{v_{0,x}} - \frac{1}{2}g\left(\frac{8}{v_{0,x}}\right)^2 \tag{16}$$

We also have to include the requirement that your friend on the other side must catch it, so that by the time the ball moves 16 meters horizontally, the ball has returned to 0 in our coordinate system. Mathimatically:

$$16 = x(t') = v_{0,x}t' \tag{17}$$

$$\Rightarrow t' = \frac{16}{v_{0,x}} \tag{18}$$

$$0 = y(t') = v_{0,y} * \frac{16}{v_{0,x}} - \frac{1}{2}g\left(\frac{16}{v_{0,x}}\right)^2 \tag{19}$$

Solving equation 16 and 19 for our two unkowns is an exercise in algebra. The solution is:

$$v_{0,x} = 7.9\frac{m}{s} \quad (20)$$

$$v_{0,y} = 9.9\frac{m}{s} \quad (21)$$

a. The minimum speed then is:

$$\boxed{v = \sqrt{v_{0,x}^2 + v_{0,y}^2} = \sqrt{(7.9)^2 + (9.9)^2} = 12.7\frac{m}{s}} \quad (22)$$

b. The angle is:

$$\boxed{\theta = \tan^{-1}\left(\frac{9.9}{7.9}\right) = 51.4^\circ} \quad (23)$$

42. The centripetal acceleration is:

$$a = \frac{v^2}{r} \quad (24)$$

We want this to equal the numerical value of g:

$$g = \frac{v^2}{r} \Rightarrow v = \sqrt{gr} \quad (25)$$

Thus:

$$v = \sqrt{9.8\frac{m}{s^2} * 75m} = 27.1\frac{m}{s} \quad (26)$$

54. First we note that 65km/h is equivalent to 18m/s.

a. The car slows down at a constant rate of $.65\frac{m}{s^2}$. The car must go through a quarter turn of radius 120m, so that it must go a total distance of:

$$d = \frac{1}{4}(2\pi r) = 188.5m \quad (27)$$

It will travel this distance in a time:

$$d = v_0 t - \frac{1}{2}a_t t^2 \quad (28)$$

$$\Rightarrow -\frac{1}{2}(.65)t^2 + 18t - 188.5 = 0 \quad (29)$$

$$\Rightarrow t = 14.0s \quad (30)$$

Thus, after this time, the car is moving with tangential velocity:

$$v = v_0 - a_t t = 18 - (.65)(14.0) = 8.9\frac{m}{s} \quad (31)$$

Therefore, the radial acceleration right before the car emerges from the turn is:

$$a_r = \frac{v^2}{r} = \frac{(8.9)^2}{120} = .66\frac{m}{s^2} \tag{32}$$

Thus, the magnitude of acceleration is:

$$\boxed{a = \sqrt{a_r^2 + a_t^2} = \sqrt{.66^2 + .65^2} = .93\frac{m}{s^2}} \tag{33}$$

b. The best way to do this is to draw a picture. One will see that the angle is:

$$\boxed{\theta = \sin^{-1}\left(\frac{a_r}{a}\right) = \sin^{-1}\left(\frac{.66}{.93}\right) = 45.2^\circ} \tag{34}$$