

Halliday ♦ Resnick ♦ Walker

FUNDAMENTALS OF PHYSICS

SIXTH EDITION

Selected Solutions

Chapter 4

4.13

4.27

4.39

4.47

13. Constant acceleration in both directions (x and y) allows us to use Table 2-1 for the motion along each direction. This can be handled individually (for Δx and Δy) or together with the unit-vector notation (for $\Delta \vec{r}$). Where units are not shown, SI units are to be understood.

(a) The velocity of the particle at any time t is given by $\vec{v} = \vec{v}_0 + \vec{a}t$, where \vec{v}_0 is the initial velocity and \vec{a} is the (constant) acceleration. The x component is $v_x = v_{0x} + a_x t = 3.00 - 1.00t$, and the y component is $v_y = v_{0y} + a_y t = -0.500t$ since $v_{0y} = 0$. When the particle reaches its maximum x coordinate at $t = t_m$, we must have $v_x = 0$. Therefore, $3.00 - 1.00t_m = 0$ or $t_m = 3.00$ s. The y component of the velocity at this time is $v_y = 0 - 0.500(3.00) = -1.50$ m/s; this is the only nonzero component of \vec{v} at t_m .

(b) Since it started at the origin, the coordinates of the particle at any time t are given by $\vec{r} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$. At $t = t_m$ this becomes

$$(3.00\hat{i})(3.00) + \frac{1}{2}(-1.00\hat{i} - 0.50\hat{j})(3.00)^2 = 4.50\hat{i} - 2.25\hat{j}$$

in meters.

27. Taking the y axis to be upward and placing the origin at the firing point, the y coordinate is given by $y = v_0 t \sin \theta_0 - \frac{1}{2} g t^2$ and the y component of the velocity is given by $v_y = v_0 \sin \theta_0 - g t$. The maximum height occurs when $v_y = 0$. Thus, $t = (v_0/g) \sin \theta_0$ and

$$y = v_0 \left(\frac{v_0}{g} \right) \sin \theta_0 \sin \theta_0 - \frac{1}{2} \frac{g(v_0 \sin \theta_0)^2}{g^2} = \frac{(v_0 \sin \theta_0)^2}{2g} .$$

39. We adopt the positive direction choices used in the textbook so that equations such as Eq. 4-22 are directly applicable. The coordinate origin is at ground level directly below impact point between bat and ball. The *Hint* given in the problem is important, since it provides us with enough information to find v_0 directly from Eq. 4-26.

- (a) We want to know how high the ball is from the ground when it is at $x = 97.5$ m, which requires knowing the initial velocity. Using the range information and $\theta_0 = 45^\circ$, we use Eq. 4-26 to solve for v_0 :

$$v_0 = \sqrt{\frac{g R}{\sin 2\theta_0}} = \sqrt{\frac{(9.8)(107)}{1}} = 32.4 \text{ m/s} .$$

Thus, Eq. 4-21 tells us the time it is over the fence:

$$t = \frac{x}{v_0 \cos \theta_0} = \frac{97.5}{(32.4) \cos 45^\circ} = 4.26 \text{ s} .$$

At this moment, the ball is at a height (above the ground) of

$$y = y_0 + (v_0 \sin \theta_0) t - \frac{1}{2} g t^2 = 9.88 \text{ m}$$

which implies it does indeed clear the 7.32 m high fence.

- (b) At $t = 4.26$ s, the center of the ball is $9.88 - 7.32 = 2.56$ m above the fence.

47. The radius of Earth may be found in Appendix C.

- (a) The speed of a person at Earth's equator is $v = 2\pi R/T$, where R is the radius of Earth (6.37×10^6 m) and T is the length of a day (8.64×10^4 s): $v = 2\pi(6.37 \times 10^6 \text{ m})/(8.64 \times 10^4 \text{ s}) = 463 \text{ m/s}$. The magnitude of the acceleration is given by

$$a = \frac{v^2}{R} = \frac{(463 \text{ m/s})^2}{6.37 \times 10^6 \text{ m}} = 0.034 \text{ m/s}^2 .$$

- (b) If T is the period, then $v = 2\pi R/T$ is the speed and $a = v^2/R = 4\pi^2 R^2/T^2 R = 4\pi^2 R/T^2$ is the magnitude of the acceleration. Thus

$$T = 2\pi\sqrt{\frac{R}{a}} = 2\pi\sqrt{\frac{6.37 \times 10^6 \text{ m}}{9.8 \text{ m/s}^2}} = 5.1 \times 10^3 \text{ s} = 84 \text{ min} .$$