1. Assuming the horizontal velocity of the ball is constant, the horizontal displacement is

$$\Delta x = v \Delta t$$

where Δx is the horizontal distance traveled, Δt is the time, and v is the (horizontal) velocity. Converting v to meters per second, we have $160\,\text{km/h} = 44.4\,\text{m/s}$. Thus

$$\Delta t = \frac{\Delta x}{v} = \frac{18.4\,\text{m}}{44.4\,\text{m/s}} = 0.414\,\text{s}\,.$$

The velocity-unit conversion implemented above can be figured "from basics" (1000 m = 1 km, 3600 s = 1 h) or found in Appendix D.

4. If the plane (with velocity v) maintains its present course, and if the terrain continues its upward slope of 4.3°, then the plane will strike the ground after traveling

$$\Delta x = \frac{h}{\tan\theta} = \frac{35\,\text{m}}{\tan 4.3^\circ} = 465.5\ \text{m} \approx 0.465\ \text{km}\ .$$

This corresponds to a time of flight found from Eq. 2-2 (with $v = v_{\text{avg}}$ since it is constant)

$$t = \frac{\Delta x}{v} = \frac{0.465\,\text{km}}{1300\,\text{km/h}} = 0.000358\ \text{h} \approx 1.3\ \text{s}\ .$$

This, then, estimates the time available to the pilot to make his correction.

5. (a) Denoting the travel time and distance from San Antonio to Houston as T and D, respectively, the average speed is

$$s_{\text{avg }1} = \frac{D}{T} = \frac{(55\,\text{km/h})\frac{T}{2} + (90\,\text{km/h})\frac{T}{2}}{T} = 72.5\ \text{km/h}$$

which should be rounded to 73 km/h.

(b) Using the fact that time = distance/speed while the speed is constant, we find

$$s_{\text{avg }2} = \frac{D}{T} = \frac{D}{\frac{D/2}{55\,\text{km/h}} + \frac{D/2}{90\,\text{km/h}}} = 68.3\ \text{km/h}$$

which should be rounded to 68 km/h.

(c) The total distance traveled ($2D$) must not be confused with the net displacement (zero). We obtain for the two-way trip

$$s_{\text{avg}} = \frac{2D}{\frac{D}{72.5\,\text{km/h}} + \frac{D}{68.3\,\text{km/h}}} = 70\ \text{km/h}\ .$$

(d) Since the net displacement vanishes, the average velocity for the trip in its entirety is zero.

(e) In asking for a *sketch*, the problem is allowing the student to arbitrarily set the distance D (the intent is *not* to make the student go to an Atlas to look it up); the student can just as easily arbitrarily set T instead of D, as will be clear in the following discussion. In the interest of saving space, we briefly describe the graph (with kilometers-per-hour understood for the slopes): two contiguous line segments, the first having a slope of 55 and connecting the origin to $(t_1, x_1) = (T/2, 55T/2)$ and the second having a slope of 90 and connecting (t_1, x_1) to (T, D) where $D = (55 + 90)T/2$. The average velocity, from the graphical point of view, is the slope of a line drawn from the origin to (T, D).

10. The velocity (both magnitude and sign) is determined by the slope of the x versus t curve, in accordance with Eq. 2-4.

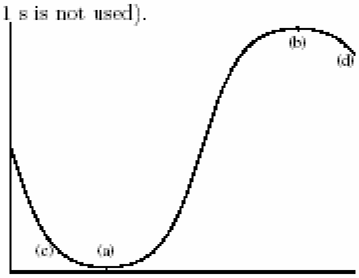
   (a) The armadillo is to the left of the coordinate origin on the axis between $t = 2.0$ s and $t = 4.0$ s.

   (b) The velocity is negative between $t = 0$ and $t = 3.0$ s.

   (c) The velocity is positive between $t = 3.0$ s and $t = 7.0$ s.

   (d) The velocity is zero at the graph minimum (at $t = 3.0$ s).

14. From Eq. 2-4 and Eq. 2-9, we note that the sign of the velocity is the sign of the slope in an x-vs-t plot, and the sign of the acceleration corresponds to whether such a curve is concave up or concave down. In the interest of saving space, we indicate sample points for parts (a)-(d) in a single figure; this means that all points are not at $t = 1$ s (which we feel is an acceptable modification of the problem – since the datum $t = 1$ s is not used).



Any change from zero to non-zero values of $\vec{v}$ represents increasing $|\vec{v}|$ (speed). Also, $\vec{v} \parallel \vec{a}$ implies that the particle is going faster. Thus, points (a), (b) and (d) involve increasing speed.

23. The constant-acceleration condition permits the use of Table 2-1.

   (a) Setting $v = 0$ and $x_0 = 0$ in $v^2 = v_0^2 + 2a(x - x_0)$, we find

$$x = -\frac{1}{2}\frac{v_0^2}{a} = -\frac{1}{2}\left(\frac{5.00 \times 10^6}{-1.25 \times 10^{14}}\right) = 0.100 \text{ m} .$$

   Since the muon is slowing, the initial velocity and the acceleration must have opposite signs.

   (b) Below are the time-plots of the position x and velocity v of the muon from the moment it enters the field to the time it stops. The computation in part (a) made no reference to t, so that other equations from Table 2-1 (such as $v = v_0 + at$ and $x = v_0 t + \frac{1}{2}at^2$) are used in making these plots.