48. The older brother can run 100 m in 100 m/(9.0 m/s) = 11.1 s, while the younger brother takes 20% longer or 13.3 s for the same distance ($\bar{v}_{\text{younger}} = \bar{v}_{\text{older}}/(120\%)$). Therefore, the slower brother should be given a head start in time of 2.2 s. (Another way to produce a tie is to give the slower brother a 16.7 m head start in distance.)

58. (**a**) and (**b**) The train goes from velocity $v_0 = 110$ km/h = 30.6 m/s (positive eastward) at $t_0 = 0$, to a stop, $v = 0$, at $t = 1.2$ min = 72 s. The constant acceleration was $a = (v - v_0)/(t - t_0) = -(30.6 \text{ m/s})/(72 \text{ s}) = -0.424 \text{ m/s}^2$. The magnitude of the acceleration is the absolute value of this, while its direction, indicated by the negative sign, was westward. (**c**) Equation 2.9 gives the stopping distance: $x - x_0 = \frac{1}{2}(v_0 + v)t = \frac{1}{2}(30.6 \text{ m/s})(72 \text{ s}) = 1.10$ km. (Equations 2.10 or 2.11 and the acceleration from part (a) could also have been used to obtain the same result.)

60. (**a**) From the given acceleration, -6.3 m/s^2, the distance traveled, 34 m, and the final velocity, 18 km/h = 5 m/s (just before the collision), the initial velocity (when the braking began) can be calculated: $v_0^2 = v^2 - 2a(x - x_0)$, or $v_0 = \sqrt{(5 \text{ m/s})^2 - 2(-6.3 \text{ m/s}^2)(34 \text{ m})} = 21.3 \text{ m/s} = 76.7$ km/h. (**b**) The deceleration time interval was $t = (v - v_0)/a = (5 \text{ m/s} - 21.3 \text{ m/s})/(-6.3 \text{ m/s}^2) = 2.59$ s. (The positive x direction is the direction in which the car was moving.)

78. If the balloon was dropped from height y_0 at time $t = 0$, then its height at any later time is $y = y_0 - \frac{1}{2}gt^2$. When it passes the top of the window, $y_1 = y_0 - \frac{1}{2}gt_1^2$, and when passing the bottom, $y_2 = y_0 - \frac{1}{2}gt_2^2$. The length of the window is $1.3 \text{ m} = y_1 - y_2 = \frac{1}{2}g(t_2^2 - t_1^2) = \frac{1}{2}g(t_2 - t_1)(t_2 + t_1)$. But $t_2 - t_1 = 0.22$ s (the time required to cross the window), so $t_2 + t_1 = 2(1.3 \text{ m})/(9.8 \text{ m/s}^2)(0.22 \text{ s}) = 1.21$ s. Combined with the value of the difference in times, we find that $t_1 = \frac{1}{2}(1.21 \text{ s} - 0.22 \text{ s}) = 0.493$ s. Finally, the height above the top of the window is $y_0 - y_1 = \frac{1}{2}gt_1^2 = \frac{1}{2}(9.8 \text{ m/s}^2)(0.493 \text{ s})^2 = 1.19$ m.

86. **Interpret** This problem involves *two* constant-acceleration problems: the falling water balloon, and the walking victims. We want to find the distance the victims walk in the time that the balloons fall.

Develop We will use $x = x_o + v_o t + \frac{1}{2}at^2$ for both problems. First, we use it to find the time it takes for our water balloons to fall. Next, we use this time and the victim's speed (with zero acceleration) to find how far the victim would move in the time that the balloon is falling. We put the X at this distance from the impact point. The initial height of the balloon is 64 ft, which we must convert to m. The constant speed of the victims is 2 m/s.

Evaluate Find the time for the balloon to fall:

$$y = y_o + v_o t + \frac{1}{2}at^2 \rightarrow 0 = y_o - \frac{1}{2}gt^2 \rightarrow t = \sqrt{\frac{2y_o}{g}}$$

Now find the distance the victim walks in that time: $x = v_{victim}t = v_{victim}\sqrt{\frac{2y_o}{g}}$.

The initial height is $y_o = 64 \text{ ft} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 19.5$ m, so

$$x = (2 \text{ m/s})\sqrt{\frac{2(19.5 \text{ m})}{9.8 \text{ m/s}^2}} = 3.99 \text{ m} \approx 4.0 \text{ m}$$

Put the X 4.0 meters from a spot directly below your dorm window.

Assess This is not a particularly good idea, since the balloons would hit at a speed of $v^2 = v_o^2 + 2a(x - x_o) \approx 20$ m/s. It will hardly endear you to your fellow students!