VP2.5.1. IDENTIFY: The bus and the car leave the same point at the same time. The bus has constant velocity, but the car starts from rest with constant acceleration. So the constant-acceleration formulas apply. We want to know how long it takes for the car to catch up to the bus and how far they both travel during that time.

SET UP: When they meet, x is the same for both of them and they have traveled for the same time. The formulas $x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$ and $v_x = v_{0x} + a_x t$ both apply.

EXECUTE: (a) When the car and bus meet, they have traveled the same distance in the same time. We apply the formula

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

to each of them, with the origin at their starting point, which makes $x_0 = 0$ for both of them. The bus has no acceleration and the car has no initial velocity. The equation reduces to

$$\frac{1}{2}a_{\text{car}}t^2 = v_{\text{bus}}t \quad \text{thus} \quad t = 2v_{\text{bus}}/a_{\text{car}}.$$

$t = 2(18\text{ m/s})/(8.0\text{ m/s}^2) = 4.5\text{ s}.$

(b) The bus has zero acceleration, so $v_x = v_{0x} + a_x t$ reduces to $x_{\text{bus}} = v_{\text{bus}}t$ and thus

$$x_{\text{bus}} = (18\text{ m/s})(4.5\text{ s}) = 81\text{ m}.$$

EVALUATE: To check, use the car's motion to find the distance.

$x_{\text{car}} = \frac{1}{2}a_{\text{car}}t^2 = \frac{1}{2}(8.0\text{ m/s}^2)(4.5\text{ s})^2 = 81\text{ m}$, which agrees with our result in part (b).

VP2.7.1. IDENTIFY: The ball is in freefall so its acceleration is g downward and the constant-acceleration equations apply.

SET UP: Calling the y-axis vertical, the formulas $y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$ and $v_y = v_{0y} + a_y t$ apply to the motion of the ball. We know that a_y = 9.80 m/s^2 downward and v_{0y} = 12.0 m/s upward.

EXECUTE: (a) At time t = 0.300 s, the vertical coordinate of the ball is given by

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2,$$

where $y_0 = 0$ at the location of the hand.

$y = 0 + (12.0 \text{ m/s})(0.300 \text{ s}) + \frac{1}{2}(-9.80 \text{ m/s}^2)(0.300 \text{ s})^2$
$= 3.16$ m.

Since y is positive, the ball is above the hand. The vertical velocity is given by

$$v_y = v_{0y} + a_y t.$$

$v_y = 12.0 \text{ m/s} + (-9.80 \text{ m/s}^2)(0.300 \text{ s}) = 9.06$ m/s.

Since v_y is positive, the ball is moving upward.

(b) At $t = 2.60$ s, $y = (12.0 \text{ m/s})(2.60 \text{ s}) + \frac{1}{2}(-9.80 \text{ m/s}^2)(2.60 \text{ s})^2 = -1.92$ m.

Since y is negative, the ball is now below the hand. The ball must be moving downward since it is now below the hand.

EVALUATE: Check with v_y: $v_y = v_{0y} + a_y t$ = 12.0 m/s + (–9.80 m/s^2)(2.60 s) = –13.5 m/s. Since v_y is negative, the ball is moving downward, as we saw above.

VP2.8.1. IDENTIFY: The rock is in freefall so its acceleration is g downward and the constant-acceleration equations apply.

SET UP: The equation $y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$ applies.

EXECUTE: (a) With the origin at the hand and the y-axis positive upward, y = 4.00 m and $y_0 = 0$. We want the time at which this occurs. The equation

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

gives 4.00 m = (12.0 m/s)t + $\frac{1}{2}$(–9.80 m/s^2)t^2. Solving this quadratic equation for t gives two answers: t = 0.398 s and t = 2.05 s.

(b) Use the same procedure as in (a) except that y = –4.00 m. This gives –4.00 m = (12.0 m/s)t + $\frac{1}{2}$(–9.80 m/s^2)t^2. This quadratic equation has two solutions, t = 2.75 s and t = –0.297 s. The negative answer is not physical (essentially before you released the ball) , so t = 2.75 s.

EVALUATE: The ball is at 4.00 m above your hand twice, when it is going up and when it is going down, so we get two answers. It is at 4.00 m below the hand only once, when it is going down, so we have just one answer.

2.6. IDENTIFY: The average velocity is $v_{\text{av-}x} = \frac{\Delta x}{\Delta t}$. Use $x(t)$ to find x for each t.

SET UP: USING THE EQUATION GIVEN

$$X = 1.5 \text{ X } T^2 - .05 \text{ X } T^3,$$

WE CAN DETERMINE DISPLACEMENT FOR THE PROVIDED TIMES.

$x(0) = 0$, $x(2.00 \text{ s}) = 5.60 \text{ m}$, and $x(4.00 \text{ s}) = 20.8 \text{ m}$

EXECUTE: **(a)** $v_{\text{av-}x} = \dfrac{5.60 \text{ m} - 0}{2.00 \text{ s}} = +2.80 \text{ m/s}$

(b) $v_{\text{av-}x} = \dfrac{20.8 \text{ m} - 0}{4.00 \text{ s}} = +5.20 \text{ m/s}$

(c) $v_{\text{av-}x} = \dfrac{20.8 \text{ m} - 5.60 \text{ m}}{2.00 \text{ s}} = +7.60 \text{ m/s}$

EVALUATE: The average velocity depends on the time interval being considered.

2.15. IDENTIFY: The average acceleration is $a_{\text{av-}x} = \dfrac{\Delta v_x}{\Delta t}$. Use $v_x(t)$ to find v_x at each t. The instantaneous acceleration is $a_x = \dfrac{dv_x}{dt}$.

SET UP:
Using the provided equation

$$v_x = 3 + .1 \text{ x } t^2$$

we can determine the velocities at each time.

$v_x(0) = 3.00\ \text{m/s}$ and $v_x(5.00\ \text{s}) = 5.50\ \text{m/s}.$

EXECUTE: **(a)**

$$a_{\text{av-}x} = \frac{\Delta v_x}{\Delta t} = \frac{5.50\ \text{m/s} - 3.00\ \text{m/s}}{5.00\ \text{s}} = 0.500\ \text{m/s}^2$$

(b) $a_x = \dfrac{dv_x}{dt} = (0.100\ \text{m/s}^3)(2t) = (0.200\ \text{m/s}^3)t.$ At $t = 0,$ $a_x = 0.$ At $t = 5.00\ \text{s},$ $a_x = 1.00\ \text{m/s}^2.$

(c) Graphs of $v_x(t)$ and $a_x(t)$ are given in Figure 2.15.

EVALUATE: $a_x(t)$ is the slope of $v_x(t)$ and increases as *t* increases. The average acceleration for $t = 0$ to $t = 5.00\text{ s}$ equals the instantaneous acceleration at the midpoint of the time interval, $t = 2.50\text{ s}$, since $a_x(t)$ is a linear function of *t*.

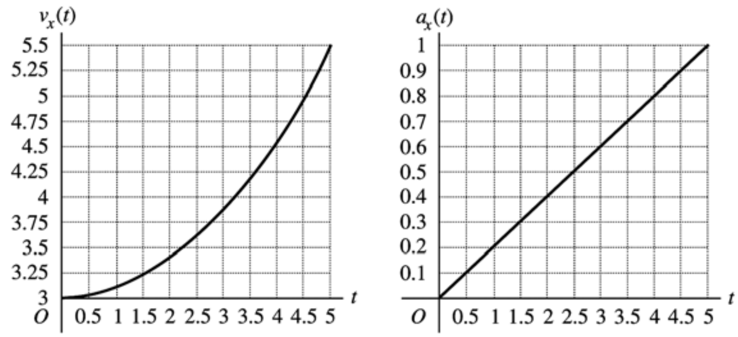

Figure 2.15

2.30. IDENTIFY: For constant acceleration, the kinematics formulas apply. We can use the total displacement and final velocity to calculate the acceleration and then use the acceleration and shorter distance to find the speed.

SET UP: Take $+x$ to be down the incline, so the motion is in the $+x$ direction. The formula $v_x^2 = v_{0x}^2 + 2a(x - x_0)$ applies.

EXECUTE: First look at the motion over 6.80 m. We use the following numbers: $v_{0x} = 0$, $x - x_0 =$ 6.80 m, and $v_x = 3.80$ /s. Solving the above equation for a_x gives $a_x = 1.06\ \text{m/s}^2$. Now look at the motion over the 3.40 m using $v_{0x} = 0$, $a_x = 1.06\ \text{m/s}^2$ and $x - x_0 = 3.40$ m. Solving the same equation, but this time for v_x, gives $v_x = 2.69$ m/s.

EVALUATE: Even though the block has traveled half way down the incline, its speed is not half of its speed at the bottom.