CHAPTER TWO SOLUTIONS

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2.3 (a) Boat A requires 1 h to cross the lake and 1 h to return, total time 2h. Boat B requires 2 h to cross the lake at which time the race is over, Boat B being on the other side of the lake or 60 km from the finish .
(b) Average velocity is the displacement of the boat divided by the time required to accomplish the displacement. The winning boat is back where it started, its displacement thus being zero yielding a zero average velocity.

2.6 (a)
$$v_{0,1} = (x_1 - x_0)/(\Delta t) = (4.0 \text{ m} - 0)/1.0 \text{ s} = +4.0 \text{ m/s}$$

(b) $v_{0,4} = (x_4 - x_0)/\Delta t = (-2.0 \text{ m} - 0)/4.0 \text{ s} = -0.5 \text{ m/s}$
(c) $v_{1,5} = (x_5 - x_1)/\Delta t = (0 - 4.0 \text{ m})/4.0 \text{ s} = -1.0 \text{ m/s}$
(d) $v_{0,5} = (x_5 - x_0)/\Delta t = (0 - 0)/5.0 \text{ s} = 0$

2.15 (a)
$$v(t = 0.50 \text{ s}) = [x(t = 1 \text{ s}) - x (t = 0)] / (1.00 \text{ s}) = +4.00 \text{ m/1.00 s} = +4.00 \text{ m/s}$$

(b) $v(t = 2s) = [x(t = 2.5 \text{ s}) - x(t = 1 \text{ s})] / (2.50 \text{ s} - 1.00 \text{ s})$
 $= (-2.0 \text{ m} - 4.0 \text{ m})/1.5 \text{ s}$
 $= -6.0 \text{ m/1.5 s} = -4.0 \text{ m/s}$
(c) $v(t=3 \text{ s}) = [x(t = 4 \text{ s}) - x(t = 2.5 \text{ s})]/(4.0s - 2.5 \text{ s})$
 $= (-2.0 \text{ m} - (-2.0 \text{ m}))/1.5 \text{ s} = 0$
(d) $v(t = 4.5 \text{ s}) = [x(t = 5 \text{ s}) - x(t = 4s)]/(5 \text{ s} - 4 \text{ s})$
 $= (0 - (-2.0 \text{ m}))/1.0 \text{ s} = + 2.0 \text{ m/s}$
2.18 $\tilde{a} = \Delta v / \Delta t = \frac{(-8.0 \text{ m/s}) - (10.0 \text{ m/s})}{12 \text{ x} 10^{-3} \text{ s}} = -1.5 \text{ x} 10^3 \text{ m/s}^2$

2.20 (a)
$$\bar{a}(0 \text{ to } 5 \text{ s}) = \Delta v / \Delta t = (0 - 0) / 5.0 \text{ s} = 0$$

 $\bar{a}(5 \text{ s to } 15 \text{ s}) = (+8.0 \text{ m/s} - (-8.0 \text{ m/s})) / (10.0 \text{ s}) = +1.6 \text{ m/s}^2.$
 $\bar{a}(0 \text{ to } 20 \text{ s}) = (+8.0 \text{ m/s} - (-8.0 \text{ m/s})) / 20.0 \text{ s} = +0.80 \text{ m/s}^2.$

- (b) At t = 2 s, the slope of the tangent line to the curve is 0. At t = 10.0 s, the slope of the tangent line is ± 1.6 m/s². At t = 18.0 s, the slope of the tangent line is 0
- 2.31 The change in velocity during the first 15.0 s is $\Delta v = a \Delta t$, or $\Delta v = (2.77 \text{ m/s}^2)(15.0 \text{ s}) = 41.55 \text{ m/s}$. Thus, the constant velocity for the 2.05 min (123 s) interval is 41.55 m/s. (a) $x = x_1 + x_2 + x_3$ $= [(0 + \frac{1}{2} (2.77 \text{ m/s}^2)(15.0 \text{ s})^2)] + [(41.55 \text{ m/s} (123 \text{ s}) + 0)]$ $+ [(41.55 \text{ m/s} (4.39 \text{ s}) + \frac{1}{2} (-9.47 \text{ m/s}^2)(4.39 \text{ s})^2)]$ = 311.6 m + 5110.6 + 91.2 m = 5513.4 m.(b) ($\bar{v}_1 = \frac{311.6 \text{ m}}{15.0 \text{ s}} = 20.8 \text{ m/s}, \bar{v}_2 = \frac{5110.6 \text{ m}}{123 \text{ s}} = 41.55 \text{ m/s},$ $\bar{v}_3 = \frac{91.2 \text{ m}}{4.39 \text{ s}} = 20.8 \text{ m/s}$, and $\bar{v}_{\text{total}} = \frac{(\Delta x)_{\text{total}}}{t_{\text{total}}} = \frac{5513.4 \text{ m}}{142.4 \text{ s}} = 38.7 \text{ m/s}.$

- 2.37 (a) Use $v^2 = v_0^2 + 2ay$ with v = 0. We have $0 = (25.0 \text{ m/s})^2 + 2(-9.80 \text{ m/s}^2)y_{\text{m}}$. This gives the maximum height, y_{m} , as $y_{\text{m}} = 31.9 \text{ m}$.
 - (b) The time to reach the highest point is found from the definition of acceleration as t = 0 25.0 m/s (-9.8 m/s²) = 2.55 s
 (c) From the symmetry of the motion, the ball takes the same amount of
 - (c) From the symmetry of the motion, the ball takes the same amount of time to reach the ground from its highest point as it does to move from the ground to its highest point. Thus, t = 2.55 s.
 - (d) We can use $v = v_0 + at$, with the position of the ball at its highest point as the origin of our coordinate system. Thus, $v_0 = 0$, and t is the time for the ball to move from its maximum height to ground level. This was found in part (c) to be 2.55 s. Thus, $v = 0 + (0.80 \text{ m/s}^2)(2.55 \text{ s}) = -25 \text{ m/s}$

$$v = 0 + (-9.80 \text{ m/s}^2)(2.55 \text{ s}) = -25 \text{ m/s}^2$$

2.40 We shall first find the height of the rocket and its velocity at the instant it runs out of fuel. The height of the rocket at this time is found from $y = v_0 t + \frac{1}{2} at^2$ as $y_1 = 0 + \frac{1}{2} (29.4 \text{ m/s}^2)(4.00 \text{ s})^2 = 235 \text{ m}$ The velocity at this height is found from $v = v_0 + at$. We have

 $v_1 = 0 + (29.4 \text{ m/s}^2)(4.00 \text{ s}) = 117.6 \text{ m/s}$

At this point, the rocket begins to behave as a freely falling body. We shall now find how much higher it rises once its fuel is exhausted by the use of $v^2 = v_0^2 + 2ay$, which yields $0 = (117.6 \text{ m/s})^2 + 2(-9.80 \text{ m/s}^2)h$. Solving this for the additional height, *h* gives h = 706 m.

Thus, the total height reached is $y_{max} = y_1 + h = 235 \text{ m} + 706 \text{ m} = 941 \text{ m}.$

2.48 (a) Choosing the balcony as the origin, we have for the first ball $v_{10} = -14.7$ m/s, and for the second ball, $v_{20} = +14.7$ m/s. Since the street is at x = -19.6 m, we have for the first ball,

 $-19.6 = -(14.7)t_1 + (-9.80)(t_1)^2/2$, or $4.9(t_1)^2 + (14.7)t_1 - 19.6 = 0$. This yields $t_1 = 1$ s or $t_1 = -4$ s. We disregard the negative value so that the first ball strikes the ground after 1 s.

For the second ball, we have $-19.6 = (14.7)t_2 + (-9.80)(t_2)^2/2$, or

 $(4.9(t_2)^2 - (14.7)t_2 - 19.6 = 0$, which gives $t_2 = 4$ s or $t_2 = -1$ s.

As before, we disregard the negative value so that the second ball strikes the ground after 4 s. The difference in time is then 3.00 s. (b) When the balls strike the ground, their velocities are:

 $v_1 = v_{10} + (-g)t_1 = -14.7 \text{ m/s} - 9.80 \text{ m/s} = -24.5 \text{ m/s},$

and $v_2 = v_{20} + (-g)t_1 = +14.7 \text{ m/s} - (9.80 \text{ m/s}^2)(4 \text{ s}) = -24.5 \text{ m/s}.$

(c) For the first ball, we have $x_1 = (-14.7)(0.8) + (-9.80)(0.8)^2/2 = -14.9$ m.

For the second ball, we have $x_2 = (+14.7)(0.8) + (-9.80)(0.8)^2/2 = 8.6$ m.

So the two balls are $x_2 - x_1 = 8.6 - (-14.9) = 23.5$ m apart.

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ANSWERS TO CONCEPTUAL QUESTIONS

6. In Figure (a) the first three images show the object moving slightly farther during each time interval. Thus, it has a positive acceleration. Between image three and four, and four and five, it moves much farther indicating a sudden increase in the magnitude of the acceleration. Finally, between image five and six, it slows, with a negative acceleration. In figure (b) the spacing between each image remains constant, so the object is moving with a constant velocity.

In Figure (c) the object has a positive acceleration.

- 12. (a) The car is moving to the east and increasing in speed.
 - (b) The car is moving to the east but slowing in speed.
 - (c) The car is moving to the east at constant speed.
 - (d) The car is moving to the west but slowing in speed.
 - (e) The car is moving to the west and speeding up.
 - (f) The car is moving to the west at constant speed.
 - (g) The car starts from rest and begins to speed up toward the east.
 - (h) The car starts from rest and begins to speed up toward the west.