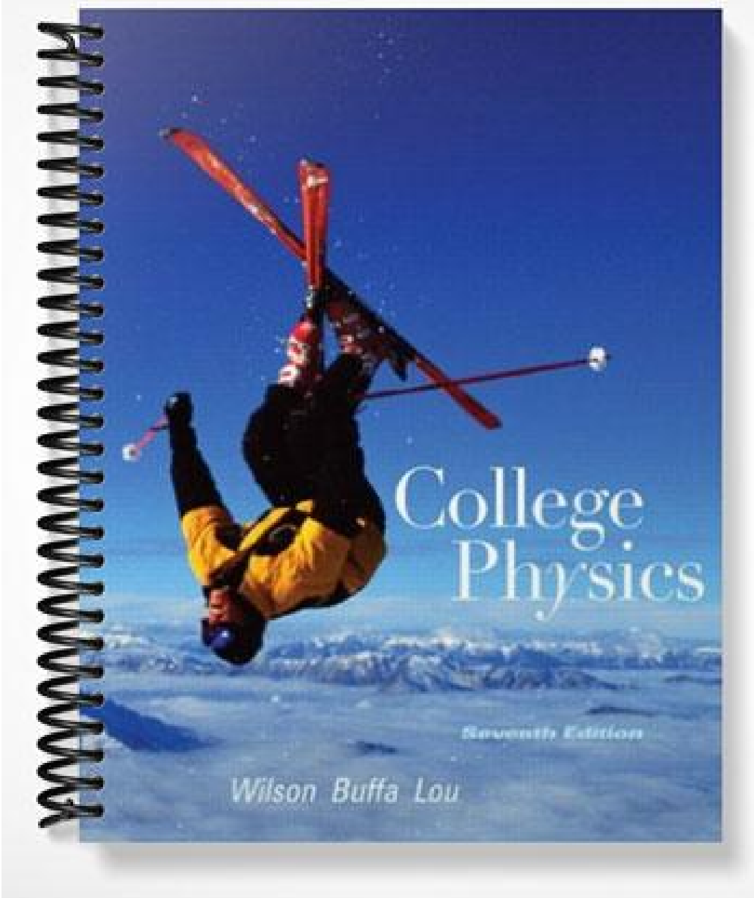
SOLUTIONS MANUAL



CHAPTER 2

KINEMATICS: DESCRIPTION OF MOTION

Multiple Choice Questions:

1. (a).

2. (d). Choice (a) can never be true; choices (b) and (c) are sometimes true; only choice (d) is always true.

3. (c).

4. (c).

5. (c). Since the magnitude of the displacement vector is a distance and the magnitude of the velocity vector is the speed, choice (c) is correct.

6. (d).

7. (d).

8. (c). A negative acceleration only means that the acceleration is pointing in the negative direction. If an object is moving in the positive x-direction, the velocity of the object decreases. But if it is moving in the negative x-direction, its velocity will increase so it will speed up.

9. (d). Any change in either magnitude or direction results in a change in velocity. The brake and gearshift change the magnitude, and the steering wheel changes the direction.

10. (b). Since acceleration is the rate of change of the velocity, a constant acceleration implies a constant rate of change of the velocity, making (b) the correct choice.

11. (c). The speed of a decelerating object is decreasing, which can only happen if the acceleration is opposite to the velocity.

12. (c). In both cases, the ratio of the velocity change to the time interval for that change is the same, which means they have the same magnitude acceleration.

13. (c).

14. (d). The graph of x as a function of t is a parabola, depending on the square of the time.

15. (a). Since $v = v_0 + at$, $\bar{v} = \frac{v_0 + v}{2} = \frac{0 + (0 + at)}{2} = \frac{1}{2}at$.

16. (d).

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

17. (d). Free fall is motion under the influence of gravity alone, and the acceleration is g. The initial velocity does not affect the acceleration.

18. (c). It accelerates at 9.80 m/s^2, so it increases its speed by 9.80 m/s during each second.

19. (a). The acceleration is not zero; it is 9.80 m/s^2 downward.

20. (c). It always accelerates at 9.80 m/s^2 downward.

Conceptual Questions:

1. Yes, for a round-trip. No; distance is always greater than or equal to the magnitude of displacement.

2. No final position can be given. It may be anywhere from 0 to 750 m from the start.

3. The distance traveled is greater than or equal to 300 m. The object could travel a variety of ways as long as it ends up at 300 m north. If the object travels straight north, then the minimum distance is 300 m.

4. No, this is generally not the case. The average velocity can be zero (e.g. a round trip), while the average speed is never zero.

5. Yes, this is possible. The jogger can jog in the opposite direction during part of the jog (negative instantaneous velocity) as long as the overall jog is in the forward direction (positive average velocity).

6. Yes, although the speed of the car is constant, its velocity is not, because of the change in direction. A change in velocity means that there is acceleration, and the velocity (a vector quantity) can change by either changing direction, magnitude or both.

7. Not necessarily. The change in velocity is the key. If a fast-moving object does not change its velocity, its acceleration is zero. However, if a slow-moving object changes its velocity, it will have some non-zero acceleration.

8. Not necessarily. A negative acceleration can cause an increase in speed if the velocity is also negative (that is, if the velocity is in the same direction as the acceleration).

9. In part (a), the object accelerates uniformly first, maintains constant velocity (zero acceleration) for a while, and then accelerates uniformly at the same rate as in the first segment. In (b), the object accelerates uniformly.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

10. The final velocity is v_o since an equal amount of time is spent on acceleration and deceleration and both of these have the same magnitude.

11. If (assuming uniform accelerations) we apply the formula v2 = vo2 + 2a(x – x0), we see that both cars have the same initial speed (v0 = 0) and the same final speed v, so the quantity a(x – x0) must be the same for both of them. Since car B travels twice as far as car A, its acceleration must therefore be half as large as that of car A, which tells us that $\boxed{a_A = 2a_B}$. Another way to view this problem is the following. Both cars have the same average speed but travel unequal distances. Car A will take less time to reach the line because it has less distance to travel. Since the change in velocities are the same, car A will have a higher rate of change of velocity, thus A's acceleration is greater than B's. Since car A travels half the distance as B at the same average speed as A, it will take half as long to finish as B. Thus A will have twice the acceleration as B.

12. It is zero because the velocity is constant.

13. Not necessarily because even if the acceleration is negative, the object can still have positive velocity (meaning it is slowing) and the result could be a positive value for x.

14. Consider the displacement $(x - x_o)$ as one quantity; there are four quantities involved in each of the kinematic equations (Eqs. 2.8, 2.10, 2.11, and 2.12). All but one of the four must be known before one can solve for any unknown.

15. Yes, if the displacement is negative meaning the object accelerates to the left.

16. When it reaches the highest point, its velocity is zero (velocity changes from up to down, so it is zero at that instant), but its acceleration is 9.80 m/s^2 downward because the velocity is changing direction, signifying acceleration (due to gravity).

17. No, since one value of the instantaneous velocity does not tell you if the velocity is changing. It could be zero just for an instant and not zero either before or after that instant, thus it could be changing and the object could be accelerating. You need two values of instantaneous velocity to determine if an object is accelerating.

18. The ball moves at constant velocity because there is no gravitational acceleration in deep space. If an object's acceleration is zero, then v is a constant, in magnitude and direction, but is not necessarily zero.

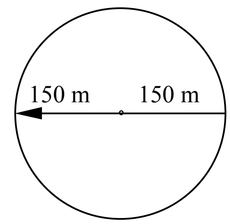
19. Since the first stone has been accelerating downward for a longer time, it will always have a higher speed and thus as time goes by it will have fallen further and thus the gap between them (Δy) will increase.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

20. First, the gravitational acceleration on the Moon is only 1/6 of that on the Earth, or $g_M = g_E/6$. Hence dropped objects take longer to reach the surface than on the Earth, and tossed objects will go higher and stay in flight longer than on Earth. Secondly, there is no air resistance on the Moon, which means that all objects, regardless of mass and/or shape, will accelerate at the same rate, whereas this is only an approximation that works well for small massive objects on the Earth.

Exercises:

1. Displacement is the change in position.



Therefore the magnitude of the displacement for half a lap is $\boxed{300\text{ m}}$.

For a full lap (the car returns to its starting position), the displacement is $\boxed{\text{zero}}$.

2. $v_{av} = d/t$, where $d = 80\text{ km} + 50\text{ km} = 130\text{ km}$

$t_1 = d_1/v_1 = (80\text{ km})/(100\text{ km/h}) = 0.800\text{ h}$

$t_2 = d_2/v_2 = (50\text{ km})/(75\text{ km/h}) = 0.667\text{ h}$

$t = t_1 + t_2 = 0.800\text{ h} + 0.667\text{ h} = 1.467\text{ h}$

$v_{av} = d/t = (130\text{ km})/(1.467\text{ h}) = \boxed{89\text{ km/h}}$

3. $t = d/v_{av}$, where $v_{av} = \dfrac{100\text{ yd}}{9.0\text{ s}}\left(\dfrac{3\text{ ft}}{1\text{ yd}}\right)\left(\dfrac{1\text{ m}}{3.281\text{ ft}}\right) = 10.16\text{ m/s}$

$t = (100\text{ m})/(10.16\text{ m/s}) = \boxed{9.8\text{ s}}$

4. (a) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{(0.30\text{ km})(1000\text{ m/km})}{(10\text{ min})(60\text{ s/min})} = \boxed{0.50\text{ m/s}}$.

(b) $\bar{s}_1 = 1.20\,\bar{s} = 1.20(0.50\text{ m/s}) = 0.60\text{ m/s}$. So $\Delta t = \dfrac{d}{\bar{s}_1} = \dfrac{300\text{ m}}{0.60\text{ m/s}} = 500\text{ s} = \boxed{8.3\text{ min}}$.

5. 1 cc = 1 mL. This is analogous to average speed.

$\Delta t = \dfrac{d}{\bar{s}} = \dfrac{500\text{ mL}}{4.0\text{ mL/min}} = \boxed{125\text{ min}}$.

6. $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{2(25\text{ m})}{[2(0.50\text{ min}) + 4.0\text{ min}](60\text{ s/min})} = \boxed{0.17\text{ m/s}}$.

7. The time going is $t_{going} = d/v_1 = (300\text{ km})/(75\text{ km/h}) = 4.00\text{ h}$

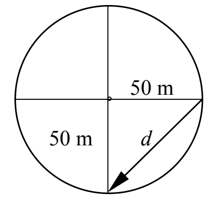
The time returning is $t_{return} = d/v_2 = (300\text{ km})/(85\text{ km/h}) = 3.53\text{ h}$

The average speed is $v_{av} = 2d/t_{total} = (600\text{ km})/(4.00\text{ h} + 3.53\text{ h} + 0.50\text{ h}) = \boxed{75\text{ km/h}}$

The average velocity is $\boxed{\text{zero}}$ because the net displacement is zero.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

8. (a) The answer is $\boxed{\text{(2) greater than } R \text{ but less than } 2R}$. For any right triangle, the hypotenuse is always greater than any one of the other two sides (R) and less than the sum of the sum of the other two sides ($R + R = 2R$).



(b) $d = \sqrt{(50\text{m})^2 + (50\text{m})^2} = \boxed{71\text{ m}}$.

9. (a) $t = \dfrac{d}{v} = \dfrac{150\text{ km}}{\left(65\dfrac{\text{mi}}{\text{h}}\right)\left(\dfrac{1\text{ km}}{0.6214\text{ mi}}\right)} = 1.43\text{ h} = \boxed{1.4\text{ h}}$

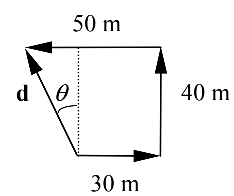
(b) $t = \dfrac{d}{v} = \dfrac{150\text{ km}}{\left(80\dfrac{\text{mi}}{\text{h}}\right)\left(\dfrac{1\text{ km}}{0.6214\text{ mi}}\right)} = 1.165\text{ h}$

The time you would *save* is 1.43 h – 1.165 h = $\boxed{0.27\text{ h}}$ or about $\boxed{16\text{ min}}$.

10. (a) The average velocity is $\boxed{\text{(1) zero}}$, because the displacement is zero for a complete lap.

(b) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{2\pi r}{\Delta t} = \dfrac{2\pi(500\text{ m})}{50\text{ s}} = \boxed{63\text{ m/s}}$.

11. (a) The magnitude of the displacement is $\boxed{\text{(3) between 40 m and 60 m}}$, because any side of a triangle cannot be greater than the sum of the other two sides. In this case, looking at the triangle shown, the two sides perpendicular to each other are 20 m and 40 m, respectively. The magnitude of the displacement is the hypotenuse of the right triangle, so it cannot be smaller than the longer of the sides perpendicular to each other.



(b) $d = \sqrt{(40\text{ m})^2 + (50\text{m} - 30\text{ m})^2} = \boxed{45\text{ m}}$. $\theta = \tan^{-1}\left(\dfrac{50\text{ m} - 30\text{ m}}{40\text{ m}}\right) = \boxed{27° \text{ west of north}}$.

12. (a) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{2(7.1\text{ m})}{2.4\text{ s}} = \boxed{5.9\text{ m/s}}$.

(b) Average velocity is $\boxed{\text{zero}}$, because the ball is caught at the initial height so $\boxed{\text{displacement is zero}}$.

13. (a) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{27\text{ m} + 21\text{ m}}{(30\text{ min})(60\text{ s/min})} = \boxed{2.7\text{ cm/s}}$.

(b) The displacement is $\Delta x = \sqrt{(27\text{ m})^2 + (21\text{ m})^2} = 34.2$ m. $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{34.2\text{ m}}{(30\text{ min})(60\text{ s/min})} = \boxed{1.9\text{ cm/s}}$.

14. (a) $\bar{v} = \dfrac{\Delta x}{\Delta t}$, so

$\bar{v}_{AB} = \dfrac{1.0\text{ m} - 1.0\text{ m}}{1.0\text{ s} - 0} = \boxed{0}$; $\bar{v}_{BC} = \dfrac{7.0\text{ m} - 1.0\text{ m}}{3.0\text{ s} - 1.0\text{ s}} = \boxed{3.0\text{ m/s}}$;

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$\bar{v}_{CD} = \dfrac{9.0\text{ m} - 7.0\text{ m}}{4.5\text{ s} - 3.0\text{ s}} = \boxed{1.3\text{ m/s}}$; $\bar{v}_{DE} = \dfrac{7.0\text{ m} - 9.0\text{ m}}{6.0\text{ s} - 4.5\text{ s}} = \boxed{-1.3\text{ m/s}}$;

$\bar{v}_{EF} = \dfrac{2.0\text{ m} - 7.0\text{ m}}{9.0\text{ s} - 6.0\text{ s}} = \boxed{-1.7\text{ m/s}}$; $\bar{v}_{FG} = \dfrac{2.0\text{ m} - 2.0\text{ m}}{11.0\text{ s} - 9.0\text{ s}} = \boxed{0}$;

$\bar{v}_{BG} = \dfrac{2.0\text{ m} - 1.0\text{ m}}{11.0\text{ s} - 1.0\text{ s}} = \boxed{0.10\text{ m/s}}$.

(b) $\boxed{\text{The motion of BC, CD, and DE are not uniform}}$, since they are not straight lines.

(c) The object changes its direction of motion at point D. So it has to stop momentarily, and $v = \boxed{0}$.

15. Use $\bar{s} = \dfrac{d}{\Delta t}$ and $\bar{v} = \dfrac{\Delta x}{\Delta t}$.

(a) $\bar{s}_{0\text{-}2.0\text{ s}} = \dfrac{2.0\text{ m} - 0}{2.0\text{ s} - 0} = \boxed{1.0\text{ m/s}}$; $\bar{s}_{2.0\text{ s-}3.0\text{ s}} = \dfrac{2.0\text{ m} - 2.0\text{ m}}{3.0\text{ s} - 2.0} = \boxed{0}$;

$\bar{s}_{3.0\text{ s-}4.5\text{ s}} = \dfrac{4.0\text{ m} - 2.0\text{ m}}{4.5\text{ s} - 3.0\text{ s}} = \boxed{1.3\text{ m/s}}$; $\bar{s}_{4.5\text{ s-}6.5\text{ s}} = \dfrac{4.0\text{ m} - (-1.5\text{ m})}{6.5\text{ s} - 4.5\text{ s}} = \boxed{2.8\text{ m/s}}$;

$\bar{s}_{6.5\text{ s-}7.5\text{ s}} = \dfrac{-1.5\text{ m} - (-1.5\text{ m})}{7.5\text{ s} - 6.5\text{ s}} = \boxed{0}$; $\bar{s}_{7.5\text{ s-}9.0\text{ s}} = \dfrac{0 - (-1.5\text{ m})}{9.0\text{ s} - 7.5\text{ s}} = \boxed{1.0\text{ m/s}}$;

(b) $\bar{v}_{0\text{-}2.0\text{ s}} = \dfrac{2.0\text{ m} - 0}{2.0\text{ s} - 0} = \boxed{1.0\text{ m/s}}$; $\bar{v}_{2.0\text{ s-}3.0\text{ s}} = \dfrac{2.0\text{ m} - 2.0\text{ m}}{3.0\text{ s} - 2.0} = \boxed{0}$;

$\bar{v}_{3.0\text{ s-}4.5\text{ s}} = \dfrac{4.0\text{ m} - 2.0}{4.5\text{ s} - 3.0\text{ s}} = \boxed{1.3\text{ m/s}}$; $\bar{v}_{4.5\text{ s-}6.5\text{ s}} = \dfrac{-1.5\text{ m} - 4.0\text{ m}}{6.5\text{ s} - 4.5\text{ s}} = \boxed{-2.8\text{ m/s}}$;

$\bar{v}_{6.5\text{ s-}7.5\text{ s}} = \dfrac{-1.5\text{ m} - (-1.5\text{ m})}{7.5\text{ s} - 6.5\text{ s}} = \boxed{0}$; $\bar{v}_{7.5\text{ s-}9.0\text{ s}} = \dfrac{0 - (-1.5\text{ m})}{9.0\text{ s} - 7.5\text{ s}} = \boxed{1.0\text{ m/s}}$.

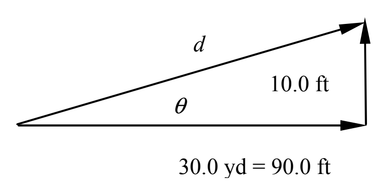
(c) $v_{1.0\text{ s}} = \bar{s}_{0\text{-}2.0\text{ s }0\text{-}2.0\text{ s}} = \boxed{1.0\text{ m/s}}$; $v_{2.5\text{ s}} = \bar{s}_{2.0\text{ s-}3.0\text{ s}} = \boxed{0}$;

$v_{4.5\text{ s}} = \boxed{0}$ since the object reverses its direction of motion; $v_{6.0\text{ s}} = \bar{s}_{4.5\text{ s-}6.5\text{ s}} = \boxed{-2.8\text{ m/s}}$.

(d) $v_{4.5\text{ s-}9.0\text{ s}} = \dfrac{0 - 4.0\text{ m}}{9.0\text{ s} - 4.5\text{ s}} = \boxed{-0.89\text{ m/s}}$.

16. (a) The magnitude of the displacement is $d = \sqrt{(90.0\text{ ft})^2 + (10.0\text{ ft})^2} = \boxed{90.6\text{ ft}}$.

$\theta = \tan^{-1}\left(\dfrac{10.0}{90.0}\right) = \boxed{6.3°\text{ above horizontal}}$.



(b) $\bar{v} = \dfrac{90.6\text{ ft at }63°}{2.5\text{ s}} = \boxed{36.2\text{ ft/s at }6.3°}$.

(c) Average speed depends on the total path length, which is not given.

The ball might take a curved path.

17. (a) At $t = 0$, $x = a = \boxed{10\text{ m}}$

(b) $\Delta x = x_4 - x_2 = a - b(4.0\text{ s})^2 - [a - b(2.0\text{ s})^2] = (0.50\text{ m/s}^2)[(2.0\text{ s})^2 - (4.0\text{ s})^2]$

$\Delta x = \boxed{-6.0\text{ m}}$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

(c) At the origin, $x = 0$: $0 = a - bt^2$

$$t = \sqrt{\frac{a}{b}} = \sqrt{\frac{10 \text{ m}}{0.50 \text{ m/s}^2}} = \boxed{4.5 \text{ s}}$$

18. (a) $\Delta x = 3(2.0 \text{ s})^2 \text{ m} - 0 = 12 \text{ m}$, and $\Delta t = 2.0$ s, so
$v_{av} = \Delta x/\Delta t = (12 \text{ m})/(2.0 \text{ s}) = \boxed{6.0 \text{ m/s}}$

(b) $\Delta x = 3(4.0 \text{ s})^2 \text{ m} - 3(2.0 \text{ s})^2 \text{ m} = 36 \text{ m}$, and $\Delta t = 2.0$ s, so

$v_{av} = \Delta x/\Delta t = (36 \text{ m})/(2.0 \text{ s}) = \boxed{18 \text{ m/s}}$

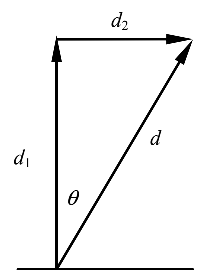
19. $d = 3.5 \text{ cm} - 1.5 \text{ cm} = 2.0 \text{ cm}$.

$$\bar{s} = \frac{d}{\Delta t}, \quad ☞ \quad \Delta t = \frac{2.0 \text{ cm}}{2.0 \text{ cm/mo}} = \boxed{1 \text{ month}}.$$

20. The minimum speed is $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{675 \text{ km}}{7.00 \text{ h}} = 96.4 \text{ km/h} = \boxed{59.9 \text{ mi/h}}$.

$\boxed{\text{No}}$, she does not have to exceed the 65 mi/h speed limit.

21. (a) See the sketch on the right.



$$d = \sqrt{(400\text{km})^2 + (300\text{km})^2} = \boxed{500 \text{ km}}.$$

$$\theta = \tan^{-1}\left(\frac{300}{400}\right) = \boxed{37° \text{ east of north}}.$$

(b) $\Delta t = 45 \text{ min} + 30 \text{ min} = 75 \text{ min} = 1.25 \text{ h}$.

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{500 \text{ km, } 37° \text{ east of north}}{1.25 \text{ h}} = \boxed{400 \text{ km/h, } 37° \text{ east of north}}.$$

(c) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{400 \text{ km} + 300 \text{ km}}{1.25 \text{ h}} = \boxed{560 \text{ km/h}}$.

(d) Since $\boxed{\text{speed involves total distance, which is greater than the magnitude of the displacement}}$, the average speed is not equal to the magnitude of the average velocity.

22. To the runner on the right, the runner on the left is running at a velocity of

$+4.50 \text{ m/s} - (-3.50 \text{ m/s}) = +8.00 \text{ m/s}$. So it takes $\Delta t = \dfrac{\Delta x}{\bar{v}} = \dfrac{100 \text{ m}}{8.00 \text{ m/s}} = \boxed{12.5 \text{ s}}$.

They meet at $(4.50 \text{ m/s})(12.5 \text{ s}) = \boxed{56.3 \text{ m (relative to runner on left)}}$.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

23. $15.0\text{ km/h} = (15.0\text{ km/h}) \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ h}}{3600\text{ s}} = 4.167\text{ m/s}$, $\quad 65.0\text{ km/h} = 18.06\text{ m/s}$.

So $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{18.06\text{ m/s} - 4.167\text{ m/s}}{6.00\text{ s}} = \boxed{2.32\text{ m/s}^2}$.

24. $60\text{ mi/h} = (60\text{ mi/h}) \times \frac{1609\text{ m}}{1\text{ mi}} \times \frac{1\text{ h}}{3600\text{ s}} = 26.8\text{ m/s}$. $\quad \bar{a} = \frac{\Delta v}{\Delta t} = \frac{26.8\text{ m/s} - 0}{3.9\text{ s}} = \boxed{6.9\text{ m/s}^2}$.

25. $\Delta t = \frac{26.8\text{ m/s} - 0}{7.2\text{ m/s}^2} = \boxed{3.7\text{ s}}$.

26. (a) The direction of the acceleration vector is $\boxed{\text{(2) opposite to velocity}}$ as the object slows down.

(b) $40.0\text{ km/h} = (40\text{ km/h}) \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ h}}{3600\text{ s}} = 11.1\text{ m/s}$.

So $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{0 - 11.1\text{ m/s}}{5.0\text{ s}} = -2.2\text{ m/s}^2$ or $\boxed{-2.2\text{ m/s each second}}$.

The negative sign indicates that the acceleration vector is in $\boxed{\text{opposite direction of velocity}}$.

27. $75\text{ km/h} = (75\text{ km/h}) \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ h}}{3600\text{ s}} = 20.8\text{ m/s}$, $\quad 30\text{ km/h} = 8.33\text{ m/s}$.

So $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{8.33\text{ m/s} - 20.8\text{ m/s}}{6.0\text{ s}} = \boxed{-2.1\text{ m/s}^2}$.

The negative sign indicates that the acceleration vector is in opposite direction of velocity.

28. (a) Once the object is released, the only force acting on it is gravity, so its acceleration is $\boxed{9.80\text{ m/s}^2}$ downward.

(b) At the instant the object is dropped, the height of the balloon is

$v^2 = v_o^2 + 2a(x - x_0)$

$(15\text{ m/s})^2 = 0 + 2(3.0\text{ m/s}^2)h \quad \rightarrow \quad h = 37.5\text{ m}$

When the ball hits the ground, its vertical position is zero and its initial position was 37.5 m. Therefore

$v^2 = v_o^2 + 2a(x - x_0)$

$v^2 = (15\text{ m/s})^2 + 2(-9.8\text{ m/s}^2)(0 - 37.5\text{ m}) \quad \rightarrow \quad v = \boxed{31\text{ m/s}}$ downward

29. (a) When they meet, x and t are the same for both cars.

$(60\text{ km/h})t = ½\,(3.0\text{ m/s}^2)t^2$

$[(60{,}000\text{ m})/(3600\text{ s})]t = 1.5\text{ m/s}^2\,t^2 \quad \rightarrow \quad t = 11.1\text{ s}$

The distance down the road is $x = ½\,at^2 = ½\,(3.0\text{ m/s}^2)(11.1\text{ s})^2 = \boxed{190\text{ m}}$

(b) From part (a), we see that $t = \boxed{11\text{s}}$.

(c) $v = v_0 + at = 0 + (3.0\text{ m/s}^2)(11.1\text{ s}) = \boxed{33\text{ m/s}}$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

30. $\bar{v} = \dfrac{v + v_o}{2} = \dfrac{v_o + 0}{2}$, ☞ $v_o = 2\,\bar{v} = \boxed{-70.0\text{ km/h}} = \boxed{-19.4\text{ m/s}}$.

$a = \dfrac{v - v_o}{t} = \dfrac{0 - (-19.4\text{ m/s})}{7.00\text{ s}} = \boxed{+2.78\text{ m/s}^2}$.

In this case, the positive 2.78 m/s^2 indicates deceleration because the velocity is negative.

31. (a) Given: $v_o = 35.0$ km/h = 9.72 m/s, $a = 1.50\text{ m/s}^2$, $x = 200$ m (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = (9.72\text{ m/s})^2 + 2(1.5\text{ m/s}^2)(200\text{ m}) = 694\text{ m}^2/\text{s}^2$, ☞ $v = \boxed{26.3\text{ m/s}}$.

(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{26.3\text{ m/s} - 9.72\text{ m/s}}{1.50\text{ m/s}^2} = \boxed{11.1\text{ s}}$.

32. Use the direction to the right as the positive direction.

$\bar{a} = \dfrac{\Delta v}{\Delta t} = \dfrac{11\text{ m/s} - (-35\text{ m/s})}{0.095\text{ s}} = \boxed{4.8 \times 10^2\text{ m/s}^2}$.

This is a very large acceleration due to the change in direction of the velocity and the short contact time.

33. $\bar{a}_{0\text{-}4.0} = \dfrac{\Delta v}{\Delta t} = \dfrac{8.0\text{ m/s} - 0}{4.0\text{ s} - 0} = \boxed{2.0\text{ m/s}^2}$; $\bar{a}_{4.0\text{-}10.0} = \dfrac{8.0\text{ m/s} - 8.0\text{ m/s}}{10.0\text{ s} - 4.0\text{ s}} = \boxed{0}$;

$\bar{a}_{10.0\text{-}18.0} = \dfrac{0 - 8.0\text{ m/s}}{18.0\text{ s} - 10.0\text{ s}} = \boxed{-1.0\text{ m/s}^2}$.

The object accelerates at 2.0 m/s^2 first, moves with constant velocity, then decelerates at 1.0 m/s^2.

34. (a) $\bar{a}_{0\text{-}1.0\text{ s}} = \dfrac{\Delta v}{\Delta t} = \dfrac{0 - 0}{1.0\text{ s} - 0} = \boxed{0}$; $\bar{a}_{1.0\text{ s-}3.0\text{ s}} = \dfrac{8.0\text{ m/s} - 0}{3.0\text{ s} - 1.0\text{ s}} = \boxed{4.0\text{ m/s}^2}$;

$\bar{a}_{3.0\text{ s-}8.0\text{ s}} = \dfrac{-12\text{ m/s} - 8.0\text{ m/s}}{8.0\text{ s} - 3.0\text{ s}} = \boxed{-4.0\text{ m/s}^2}$; $\bar{a}_{8.0\text{ s-}9.0\text{ s}} = \dfrac{-4\text{ m/s} - (-12.0\text{ m/s})}{9.0\text{ s} - 8.0\text{ s}} = \boxed{8.0\text{ m/s}^2}$;

$\bar{a}_{9.0\text{ s-}13.0\text{ s}} = \dfrac{-4.0\text{ m/s} - 4.0\text{ m/s}}{13.0\text{ s} - 9.0\text{ s}} = \boxed{0}$.

(b) $\boxed{\text{Constant velocity of } -4.0\text{ m/s}}$.

35. (a) See the sketch on the right.

(b) The acceleration is negative as the object slows down (assume velocity is positive).

$v = v_o + at = 25\text{ m/s} + (-5.0\text{ m/s}^2)(3.0\text{ s})$

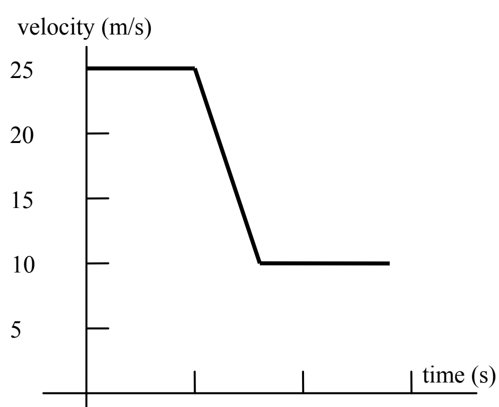
$= \boxed{10\text{ m/s}}$.

(c) $x = x_1 + x_2 + x_3$

$= (25\text{ m/s})(5.0\text{ s})$

$+ (25\text{ m/s})(3.0\text{ s}) + \frac{1}{2}(-5.0\text{ m/s}^2)(3.0\text{ s})^2$

$+ (10\text{ m/s})(6.0\text{ s})$



Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$= 237.5\text{ m} = \boxed{2.4 \times 10^2\text{ m}}.$

(d) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{237.5\text{ m}}{14.0\text{ s}} = \boxed{17\text{ m/s}}.$

36. $72\text{ km/h} = (72\text{ km/h}) \times \dfrac{1000\text{ m}}{1\text{ km}} \times \dfrac{1\text{ h}}{3600\text{ s}} = 20\text{ m/s}.$

During deceleration, $\Delta t_1 = \dfrac{\Delta v}{\bar{a}} = \dfrac{0 - 20\text{ m/s}}{-1.0\text{ m/s}^2} = 20\text{ s}$; $\Delta x_1 = \bar{v}_1\,\Delta t_1 = \dfrac{20\text{ m/s} + 0}{2}(20\text{ s}) = 200\text{ m}.$

It would have taken the train $\dfrac{200\text{ m}}{20\text{ m/s}} = 10\text{ s}$ to travel 200 m.

So it lost only 20 s – 10 s = 10 s during deceleration.

During acceleration, $\Delta t_2 = \dfrac{20\text{ m/s} - 0}{0.50\text{ m/s}^2} = 40\text{ s}$; $\Delta x_2 = \dfrac{0 + 20\text{ m/s}}{2}(40\text{ s}) = 400\text{ m}.$

It would have taken the train $\dfrac{400\text{ m}}{20\text{ m/s}} = 20\text{ s}$ to travel 400 m. So it lost only 40 s – 20 s = 20 s during acceleration.

Therefore, the train lost 2 min + 10 s + 20 s = $\boxed{150\text{ s}}$ in stopping at the station.

37. The average velocity is $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{100\text{ m}}{4.5\text{ s}} = 22.2\text{ m/s}.$ $\bar{v} = \dfrac{v_o + v}{2} = \dfrac{v}{2}.$

So the final velocity must be $v = 2(22.2\text{ m/s}) = 44.4\text{ m/s}.$

$\bar{a} = \dfrac{\Delta v}{\Delta t}$, ☞ $\Delta t = \dfrac{\Delta v}{\bar{a}} = \dfrac{44.4\text{ m/s} - 0}{9.0\text{ m/s}^2} = 4.9\text{ s} > 4.5\text{ s}.$

So $\boxed{\text{no}}$, the driver did not do it. The acceleration must be $\dfrac{44.4\text{ m/s} - 0}{4.5\text{ s}} = \boxed{9.9\text{ m/s}^2}.$

38. Given: $v_o = 0$, $a = 2.0\text{ m/s}^2$, $t = 5.00\text{ s}$. Find: v and x (take $x_o = 0$).

(a) $v = v_o + at = 0 + (2.0\text{ m/s}^2)(5.0\text{ s}) = \boxed{10\text{ m/s}}.$

(b) $x = x_o + v_o t + \frac{1}{2}at^2 = 0 + 0(5.00\text{ s}) + \frac{1}{2}(2.0\text{ m/s}^2)(5.0\text{ s})^2 = \boxed{25\text{ m}}.$

39. Given: $v_o = 25\text{ mi/h} = 11.2\text{ m/s}$, $v = 0$, $x = 35\text{ m}$ (take $x_o = 0$). Find: a and t.

(a) $v^2 = v_o^2 + 2a(x - x_o)$, ☞ $a = \dfrac{v^2 - v_o^2}{2x} = \dfrac{(0)^2 - (11.2\text{ m/s})^2}{2(35\text{ m})} = -1.79\text{ m/s}^2 = -\boxed{1.8\text{ m/s}^2}.$

The negative sign indicates that the acceleration vector is in the opposite direction of the velocity.

(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{0 - 11.2\text{ m/s}}{-1.79\text{ m/s}^2} = \boxed{6.3\text{ s}}.$

40. Given: $v_o = 60\text{ km/h} = 16.7\text{ m/s}$, $v = 40\text{ km/h} = 11.1\text{ m/s}$, $x = 50\text{ m}$ (take $x_o = 0$). Find: a.

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $a = \dfrac{v^2 - v_o^2}{2x} = \dfrac{(11.1\text{ m/s})^2 - (16.7\text{ m/s})^2}{2(50\text{ m})} = \boxed{-1.6\text{ m/s}^2}.$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

41. (a) Given: $v_o = 100 \text{ km/h} = 27.78 \text{ m/s}$, $a = -6.50 \text{ m/s}^2$, $x = 20.0 \text{ m}$ (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = (27.78 \text{ m/s})^2 + 2(-6.50 \text{ m/s}^2)(20.0 \text{ m}) = 511.6 \text{ m}^2/\text{s}^2$,

So $v = 22.62 \text{ m/s} = \boxed{81.4 \text{ km/h}}$.

(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{22.62 \text{ m/s} - 27.78 \text{ m/s}}{-6.50 \text{ m/s}^2} = \boxed{0.794 \text{ s}}$.

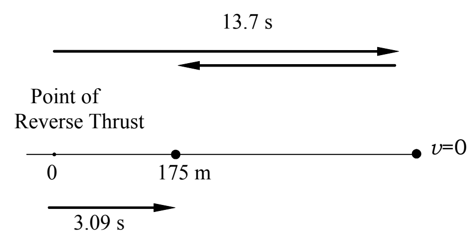
42. (a) $v = v_0 + at = 20 \text{ m/s} + (-0.75 \text{ m/s}^2)(10 \text{ s}) = \boxed{13 \text{ m/s}}$

(b) $x = v_0 t + \frac{1}{2} at^2 = (20 \text{ m/s})(10 \text{ s}) + \frac{1}{2}(-0.75 \text{ m/s}^2)(10 \text{ s})^2 = \boxed{160 \text{ m}}$

43. Given: $v_o = 250 \text{ km/h} = 69.44 \text{ m/s}$, $a = -8.25 \text{ m/s}^2$, $x = 175 \text{ m}$ (Take $x_o = 0$). Find: t.

$x = x_o + v_0 t + \frac{1}{2}at^2$, so

$175 \text{ m} = 0 + (69.44 \text{ m/s})t + \frac{1}{2}(-8.25 \text{ m/s}^2)t^2$.



Reduce to quadratic equation,

$4.125\, t^2 - 69.44\, t + 175 = 0$.

Solving, $t = \boxed{3.09 \text{ s and } 13.7 \text{ s}}$.

The 13.7 s answer is physically possible but not likely in reality.

After 3.09 s, it is 175 m from where the reverse thrust was applied, but the rocket keeps traveling forward while slowing down. Finally it stops. However, if the reverse thrust is continuously applied (which is possible, but not likely), it will reverse its direction and go back to 175 m from the point where the initial reverse thrust was applied; a process that would take 13.7 s.

44. (a) Given: Car A: $a_A = 3.00 \text{ m/s}^2$, $v_o = 2.50 \text{ m/s}$, $t = 10 \text{ s}$.

Car B: $a_B = 3.00 \text{ m/s}^2$, $v_o = 5.00 \text{ m/s}$, $t = 10 \text{ s}$.

Find: Δx (taking $x_o = 0$).

From $x = x_o + v_0 t + \frac{1}{2}at^2$, $x_A = 0 + (2.50 \text{ m/s})(10 \text{ s}) + \frac{1}{2}(3.00 \text{ m/s})^2(10 \text{ s})^2 = 175 \text{ m}$,

$x_B = 0 + (5.00 \text{ m/s})(10 \text{ s}) + \frac{1}{2}(3.00 \text{ m/s})^2(10 \text{ s})^2 = 200 \text{ m}$.

So $\Delta x = x_B - x_A = 200 \text{ m} - 175 \text{ m} = \boxed{25 \text{ m}}$.

(b) From $v = v_o + at$, $v_A = 2.50 \text{ m/s} + (3.00 \text{ m/s})(10 \text{ s}) = 32.5 \text{ m/s}$,

$v_B = 5.00 \text{ m/s} + (3.00 \text{ m/s})(10 \text{ s}) = 35.0 \text{ m/s}$.

So $\boxed{\text{car B}}$ is faster.

45. If the acceleration is less than 4.90 m/s^2, then there is friction.

Given: $v_o = 0$, $x = 15.00 \text{ m}$ (take $x_o = 0$), $t = 3.0 \text{ s}$. Find: a.

$x = x_o + v_0 t + \frac{1}{2}at^2$, ☞ $15.00 \text{ m} = 0 + \frac{1}{2}a(3.0 \text{ s})^2$.

$a = 3.33 \text{ m/s}^2$. So the answer is $\boxed{\text{no}}$, the incline is not frictionless.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

46. (a) $\boxed{\text{(3) The object will travel in the } +x\text{-direction and then reverse its direction}}$. This is because the object has initial velocity in the $+x$-direction, and it takes time for the object to decelerate, stop, and then reverse direction. We take $x_o = 0$.

Given: $v_o = 40$ m/s, $a = -3.5$ m/s^2, $x = 0$ ("returns to the origin"). Find: t and v.

(b) $x = x_o + v_o t + \frac{1}{2}at^2$, ☞ $0 = 0 + (40 \text{ m/s})t + \frac{1}{2}(-3.5 \text{ m/s}^2)t^2$.

Reduce to quadratic equation: $1.75t^2 - 40t = 0$. Solving, $t = 0$ or 22.9 s.

The $t = 0$ answer corresponds to the initial time. So the answer is $t = \boxed{23 \text{ s}}$.

(c) $v = v_o + at = 40 \text{ m/s} + (-3.5 \text{ m/s}^2)(22.9 \text{ s}) = -40 \text{ m/s} = \boxed{40 \text{ m/s in the } -x\text{-direction}}$.

47. Given: $v_o = 330$ m/s, $v = 0$, $x = 25$ cm $= 0.25$ m (Take $x_o = 0$). Find: a.

$$v^2 = v_o^2 + 2a(x - x_o), \quad ☞ \quad a = \frac{v^2 - v_o^2}{2x} = \frac{(0)^2 - (330 \text{ m/s})^2}{2(0.25 \text{ m})} = -\boxed{2.2 \times 10^5 \text{ m/s}^2}.$$

The negative sign here indicates that the acceleration vector is in the opposite direction of the velocity.

48. $$40 \text{ km/h} = (40 \text{ km/h}) \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 11.11 \text{ m/s}.$$

During the reaction time, the car travels a distance of $d = (11.11 \text{ m/s})(0.25 \text{ s}) = 2.78$ m.

So the car really has only 13 m – 2.78 m = 10.2 m to come to rest.

Let's calculate the stopping distance of the car. We take $x_o = 0$.

Given: $v_o = 11.1$ m/s, $v = 0$, $a = -8.0$ m/s^2. Find: x. (Take $x_o = 0$.)

$$v^2 = v_o^2 + 2a(x - x_o), \quad ☞ \quad x = \frac{v^2 - v_o^2}{2a} = \frac{0 - (11.1 \text{ m/s})^2}{2(-8.0 \text{ m/s}^2)} = 7.70 \text{ m}.$$

So it takes the car only 2.78 m + 7.70 m = $\boxed{10.5 \text{ m}}$ (< 13 m) to stop.

$\boxed{\text{Yes}}$, the car will stop before hitting the child.

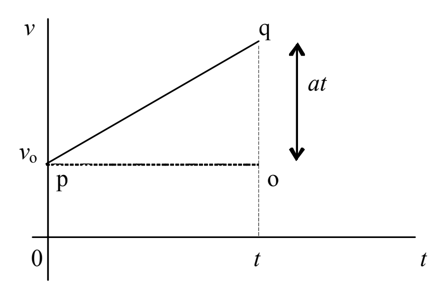
49. Repeat the calculation of Exercise 2.48. $d = (11.1 \text{ m/s})(0.50 \text{ s}) = 5.55$ m.

5.55 m + 7.70 m = $\boxed{13.3 \text{ m}}$ > 13 m. $\boxed{\text{No}}$, the car will not stop before hitting the child.

50. Given: $v_o = 350$ m/s, $v = 210$ m/s, $x = 4.00$ cm $= 0.0400$ m (take $x_o = 0$). Find: t.

$$x = x_o + \bar{v}\,t = \frac{v_o + v}{2}\,t, \quad ☞ \quad t = \frac{2x}{v_o + v} = \frac{2(0.0400 \text{ m})}{350 \text{ m/s} + 210 \text{ m/s}} =$$

$\boxed{1.43 \times 10^{-4} \text{ s}}$.



51. (a) For constant acceleration, the v vs. t plot is a straight line.

Point p has coordinates of $(0, v_o)$ and point q has coordinates of

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$(t, v_o + at)$. The distance from point q to point o is therefore at. The area under the curve is the area of the triangle $\frac{1}{2}(at)t$ plus the area of the rectangle $v_o t$.

So $A = v_o t + \frac{1}{2}at^2 = x - x_o$. (Here $x - x_o$ is displacement.)

(b) The total area consists of two triangles from 0 to 4.0 s and from 10.0 s to 18.0 s and a rectangle from 4.0 s to 10.0 s.

$x - x_o = A = \frac{1}{2}(4.0\text{ s} - 0)(8.0\text{ m/s}) + (10.0\text{ s} - 4.0\text{ s})(8.0\text{ m/s}) + \frac{1}{2}(18.0\text{ s} - 10.0\text{ s})(8.0\text{ m/s}) = \boxed{96\text{ m}}$.

52. (a) $\boxed{(3)\ t_1 > t_2}$. Since the object is accelerating, it will spend less time in traveling the second 3.00 m.

(b) For the first 3.00 m: Given: $v_o = 0$, $a = 2.00\text{ m/s}^2$, $x = 3.00$ m (take $x_o = 0$). Find: t.

$x = x_o + v_o t + \frac{1}{2}at^2 = 0 + 0 + \frac{1}{2}at^2$, ☞ $t_1 = \sqrt{\frac{2x}{a}} = \sqrt{\frac{2(3.00\text{ m})}{2.00\text{ m/s}^2}} = \boxed{1.73\text{ s}}$.

At the end of the first 3.00 m, the velocity of the object is $v = v_o + at = 0 + (2.00\text{ m/s}^2)(1.73\text{ s}) = 3.46\text{ m/s}$. This is then the initial velocity for the second 3.00 m.

For the second 3.00 m: Given: $v_o = 3.46$ m/s, $a = 2.00\text{ m/s}^2$, $x = 3.00$ m. Find: t.

$x = x_o + v_o t + \frac{1}{2}at^2$, ☞ $3.00\text{ m} = 0 + (3.46\text{ m/s})t_2 + \frac{1}{2}(2.00\text{ m/s}^2)t_2^2$.

Reducing to quadratic equation, $t^2 + 3.46t - 3.00 = 0$.

Solving, $t_2 = \boxed{0.718\text{ s}}$ or -4.18 s.

53. (a) At the end of phase 1, the change in velocity is $v_1 - 0 = v_1$. At the end of phase 2, the change in velocity is $v_2 - v_1$. Since the object is accelerating, it spends less time in phase 2 than in phase 1. Since the change in velocity is equal to acceleration times the time, the change in velocity is greater in phase 1 than in phase 2. Or $v_1 > v_2 - v_1$. That is $2v_1 > v_2$.

Therefore, $v_1 > \frac{1}{2}v_2$. The answer is $\boxed{(3)\ v_1 > \frac{1}{2}v_2}$.

(b) For phase 1: $v_o = 0$, $a = 0.850\text{ m/s}^2$, $x = 50.0$ m (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = 0^2 + 2(0.850\text{ m/s}^2)(50.0\text{ m}) = 85.0\text{ m}^2/\text{s}^2$, ☞ $v_1 = \boxed{9.22\text{ m/s}}$.

For phase 2: $v_o = 9.22$ m/s, $a = 0.850\text{ m/s}^2$, $x = 50.0$ m (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = (9.22\text{ m/s})^2 + 2(0.850\text{ m/s}^2)(50.0\text{ m}) = 170\text{ m}^2/\text{s}^2$, ☞ $v_2 = \boxed{13.0\text{ m/s}}$.

So $v_1 = 9.22\text{ m/s} > \frac{1}{2}v_2 = \frac{1}{2}(13.0\text{ m/s}) = 6.50\text{ m/s}$.

54. Take $x_o = 0$. During acceleration: $v_o = 0$, $a = 1.5\text{ m/s}^2$, $t = 6.0$ s.

$x_1 = x_o + v_o t + \frac{1}{2}at^2 = 0 + 0 + \frac{1}{2}(1.5\text{ m/s}^2)(6.0\text{ s})^2 = 27\text{ m}$,

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$v = v_o + at = 0 + (1.5\text{ m/s}^2)(6.0\text{ s}) = 9.0\text{ m/s}.$

During constant velocity: $x_2 = (9.0\text{ m/s})(8.0\text{ s}) = 72\text{ m}.$

So $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{27\text{ m} + 72\text{ m}}{14\text{ s}} = \boxed{7.1\text{ m/s}}.$

55. (a) $v(8.0\text{ s}) = \boxed{-12\text{ m/s}}$; $v(11.0\text{ s}) = \boxed{-4.0\text{ m/s}}$.

(b) Use the result of Exercise 2.51a. The total area consists of a rectangle from 0 to 1.0 s, a triangle from 1.0 s to 5.0 s, a trapezoid from 5.0 s to 11.0 s, and a triangle from 6.0 s to 9.0 s with baseline at –4.0 m/s.

$$x - x_o = A = 0 + \tfrac{1}{2}(5.0\text{ s} - 1.0\text{ s})(8.0\text{ m/s}) + \frac{(11.0\text{ s} - 6.0\text{ s}) + (11.0\text{ s} - 5.0\text{ s})}{2} \times (-4.0\text{ m/s})$$

$$+ \tfrac{1}{2}(9.0\text{ s} - 6.0\text{ s})[(-12.0\text{ m/s}) - (-4.0\text{ m/s})] = \boxed{-18\text{ m}}.$$

(c) The total distance (not displacement) is the addition of the absolute values of the areas.

$$d = \Sigma A_i = 0 + \tfrac{1}{2}(5.0\text{ s} - 1.0\text{ s})(8.0\text{ m/s}) + \frac{(11.0\text{ s} - 6.0\text{ s}) + (11.0\text{ s} - 5.0\text{ s})}{2} \times (4.0\text{ m/s})$$

$$+ \tfrac{1}{2}(9.0\text{ s} - 6.0\text{ s})[(12.0\text{ m/s} - 4.0\text{ m/s}] = \boxed{50\text{ m}}.$$

56. (a) $v^2 = v_o^2 + 2a(x - x_o)$, ☞ $x - x_o = \dfrac{v^2 - v_o^2}{2a} = \dfrac{0^2 - v_o^2}{2a} = -\dfrac{v_0^2}{2a}.$

Taking $x_o = 0$, so $(x - x_o) = x$ is proportional to v_o^2. If v_o doubles, then x becomes 4 times as large.

The answer is then $\boxed{(3)\ 4x}$.

(b) $\dfrac{x_2}{x_1} = \dfrac{v_{2o}^2}{v_{1o}^2} = \dfrac{60^2}{40^2} = 2.25.$ So $x_2 = 2.25\,x_1 = 2.25\,(3.00\text{ m}) = \boxed{6.75\text{ m}}.$

57. (a) Given: $a = 3.00\text{ m/s}^2$, $t = 1.40\text{ s}$, $x = 20.0\text{ m}$ (take $x_o = 0$). Find: v_o.

$x = x_o + v_o t + \tfrac{1}{2}at^2$, ☞ $20.0\text{ m} = 0 + v_o(1.40\text{ s}) + \tfrac{1}{2}(3.00\text{ m/s}^2)(1.40\text{ s})^2.$

Solving, $v_o = \boxed{12.2\text{ m/s}}.$

$v = v_o + at = 12.2\text{ m/s} + (3.00\text{ m/s}^2)(1.40\text{ s}) = \boxed{16.4\text{ m/s}}.$

(b) Given: $v_o = 0$, $a = 3.00\text{ m/s}^2$, $v = 12.2\text{ m/s}$. Find: x (take $x_o = 0$).

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $x - x_o = \dfrac{v^2 - v_o^2}{2a} = \dfrac{(12.2\text{ m/s})^2 - 0^2}{2(3.00\text{ m/s}^2)} = \boxed{24.8\text{ m}}.$

(c) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{12.2\text{ m/s} - 0}{3.00\text{ m/s}^2} = \boxed{4.07\text{ s}}.$

58. 75.0 mi/h = 33.5 m/s.

(a) Given: $v_o = 33.5\text{ m/s}$, $a = -1.00\text{ m/s}^2$, $x = 100\text{ m}$ (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = (33.5\text{ m/s})^2 + 2(-1.00\text{ m/s}^2)(100\text{ m}) = 922\text{ m}^2/\text{s}^2.$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

So $v = \boxed{30.4 \text{ m/s}}$.

(b) The initial velocity on dry concrete is then 30.4 m/s. Consider on dry concrete.

Given: $v_o = 30.4$ m/s, $a = -7.00$ m/s^2, $v = 0$ m. Find: x.

$$v^2 = v_o^2 + 2ax, \quad ☞ \quad x = \frac{v^2 - v_o^2}{2a} = \frac{0^2 - (30.4 \text{ m/s})^2}{2(-7.00 \text{ m/s}^2)} = 66.0 \text{ m}.$$

So the total distance is 100 m + 66.0 m = $\boxed{166 \text{ m}}$.

(c) Use $v = v_o + at$.

On ice: $$t_1 = \frac{v - v_o}{a} = \frac{30.4 \text{ m/s} - 33.5 \text{ m/s}}{-1.00 \text{ m/s}^2} = 3.10 \text{ s},$$

On dry concrete: $$t_2 = \frac{0 - 30.4 \text{ m/s}}{-7.00 \text{ m/s}^2} = 4.34 \text{ s}.$$

So the total time is 3.10 s + 4.34 s = $\boxed{7.44 \text{ s}}$.

59. (a) Given: $v_o = 0$, $t = 2.8$ s. Find: v (take $y_o = 0$).

$v = v_o - gt = 0 - (9.80 \text{ m/s}^2)(2.8 \text{ s}) = -\boxed{27 \text{ m/s}}$.

(b) $y = y_o + v_o t - \frac{1}{2}gt^2 = 0 + 0 - \frac{1}{2}(9.80 \text{ m/s}^2)(2.8 \text{ s})^2 = -\boxed{38 \text{ m}}$.

60. (a) We take $y_o = 0$. $y = y_o + v_o t - \frac{1}{2}gt^2 = -\frac{1}{2}gt^2$. So y is proportional to the time squared.

Therefore twice the time means $\boxed{\text{(3) four times}}$ the height.

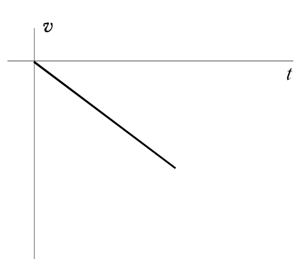
Given: $v_o = 0$, $t = 1.80$ s. Find: y_A and y_B.

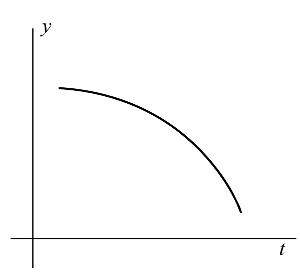
(b) $y_A = -\frac{1}{2}(9.80 \text{ m/s}^2)(1.80 \text{ s})^2 = -15.9$ m.

So the height of cliff A above the water is 15.88 m = $\boxed{15.9 \text{ m}}$.

$$y_B = \frac{y_A}{4} = \frac{15.88 \text{ m}}{4} = \boxed{3.97 \text{ m}}.$$

61. (a) A straight line (linear), slope = $-g$. (b) A parabola.





Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

62. Given: $v_o = 0$, $y = -0.157$ m (take $y_o = 0$). Find: t.

$$y - y_o = v_o t - \tfrac{1}{2}gt^2 = -\tfrac{1}{2}gt^2, \quad ☞ \quad t = \sqrt{\frac{2y}{-g}} = \sqrt{\frac{2(-0.157\text{ m})}{-9.80\text{ m/s}^2}} = 0.18\text{ s} < 0.20\text{ s}.$$

It takes less than the average human reaction time for the dollar bill to fall.

So the answer is $\boxed{\text{no, not a good deal}}$.

63. If the ball is in the air for twice as long on the second toss as it is on the first toss, the time for it to fall from its maximum height on the second toss will be twice as long as the time for it to fall from its maximum height on the first toss. Realizing that $t_2 = 2t_1$, the maximum heights reached are

$$h_1 = \tfrac{1}{2}gt_1^2$$
$$h_2 = \tfrac{1}{2}gt_2^2 = \tfrac{1}{2}g(2t_1)^2 = 2gt_1^2$$

Taking the ratio of the heights gives

$$\frac{h_2}{h_1} = \frac{2gt_1^2}{\frac{1}{2}gt_1^2} = 4$$

Therefore $h_2 = 4h_1$, so it must be tossed $\boxed{\text{4 times as high}}$.

64. Given: $v_o = 15$ m/s, $v = 0$ (maximum height). Find: y. (Take $y_o = 0$.)

$$v^2 = v_o^2 - 2g(y - y_o), \quad ☞ \quad y = \frac{v_o^2 - v^2}{2g} = \frac{(15\text{ m/s})^2 - (0)^2}{2(9.80\text{ m/s}^2)} = \boxed{11\text{ m}}.$$

65. From Exercise 2.64, $y = \dfrac{v_o^2 - v^2}{2g} = \dfrac{(15\text{ m/s})^2 - (0)^2}{2(1.67\text{ m/s}^2)} = \boxed{67\text{ m}}$.

66. Taking $y_o = 0$, $y = y_o + v_o t - \frac{1}{2}gt^2 = 0 + 0 - \frac{1}{2}gt^2 = -\frac{1}{2}gt^2$, so $t = \sqrt{\dfrac{-2y}{g}}$.

For $y = -452$ m, $t = 9.604$ s; for $y = -443$ m, $t = 9.508$ s. So $\Delta t = 9.604\text{ s} - 9.508\text{ s} = \boxed{0.096\text{ s}}$.

67. First convert 100 km/h to m/s, giving 100 km/h = 27.78 m/s. Now use the formula $v^2 = v_0^2 + 2a(x - x_0)$ and solve for x.

$(27.78\text{ m/s})^2 = 0 + 2(9.80\text{ m/s}^2)x \quad \rightarrow \quad x = \boxed{39.4\text{ m}}$

68. Given: $v_o = 6.0$ m/s, $y = -12$ m (take $y_o = 0$). Find: t and v.

(a) $y = y_o + v_o t - \frac{1}{2}gt^2$, ☞ $-12\text{ m} = 0 + (6.0\text{ m/s})t - \frac{1}{2}(9.80\text{ m/s}^2)t^2$.

Or $4.9t^2 - 6.0t - 12 = 0$. Solving, $t = \boxed{2.3\text{ s}}$ or -1.1 s. The negative time is discarded.

(b) $v = v_o - gt = 6.0\text{ m/s} - (9.80\text{ m/s}^2)(2.29\text{ s}) = -\boxed{16\text{ m/s}}$.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

69. (a) When the ball rebounds, it is a free fall with an initial upward velocity. At the maximum height, the velocity is zero. Taking $y_o = 0$,

$$v^2 = v_o^2 - 2g(y - y_o), \quad ☞ \quad y = \frac{v_o^2 - v^2}{2\,g}. \quad \text{So} \quad y_{\max} = \frac{v_o^2}{2\,g}.$$

Therefore, the height depends on the initial velocity squared. 95% = 0.95 and $0.95^2 = 0.90 < 0.95$.

The ball would bounce $\boxed{\text{(1) less than 95\%}}$ of the initial height.

(b) First calculate the speed just before impact.

Given: $v_o = 0$, $y = -4.00$ m. Find: v.

$$v^2 = v_o^2 - 2gy = 0^2 - 2(9.80\text{ m/s}^2)(-4.00\text{ m}) = 78.4\text{ m}^2/\text{s}^2,$$

so $v = -\sqrt{78.4\text{ m}^2/\text{s}^2} = -8.85$ m/s.

Therefore the speed right after the rebound is 0.950(8.85 m/s) = 8.41 m/s.

Now consider the rising motion.

Given: $v_o = 8.41$ m/s, $v = 0$ (max height). Find: y.

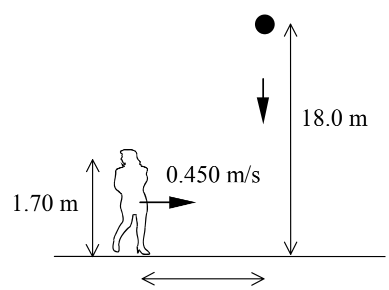
$$v^2 = v_o^2 - 2gy, \quad ☞ \quad y = \frac{v_o^2 - v^2}{2\,g} = \frac{(8.41\text{ m/s})^2 - 0^2}{2(9.80\text{ m/s}^2)} = \boxed{3.61\text{ m}}.$$

70. First find the time it takes for the ball to reach the level of the professor's head.

Given: $(y - y_o) = -(18.0\text{ m} - 1.70\text{ m}) = -16.3$ m, $v_o = 0$. Find: t.

From $y = y_o + v_o t - \frac{1}{2}gt^2 = y_o + -\frac{1}{2}gt^2$,

$$t = \sqrt{-\frac{2(y - y_o)}{g}} = \sqrt{-\frac{2(-16.3\text{ m})}{9.80\text{ m/s}^2}} = 1.824\text{ s}.$$



During this time, the professor advances a distance equal to

(0.450 m/s)(1.824 s) = 0.821 m < 1.00 m. $\boxed{\text{No}}$, it does not hit her.

Now calculate the time it takes for the ball to hit the ground.

$$t = \sqrt{-\frac{2(-18.0\text{ m})}{9.80\text{ m/s}^2}} = 1.917\text{ s}.$$

During this time, the professor advances a distance of (0.450 m/s)(1.917 s) = 0.862 m < 1.00 m.

So the ball hits 1.00 m – 0.862 m = 0.14 m = $\boxed{\text{14 cm in front of the professor}}$.

71. (a) Given: $v_o = 12.50$ m/s (ascending), $y = -60.0$ m (take $y_o = 0$). Find: t.

$$y = y_o + v_o t - \tfrac{1}{2}gt^2, \quad ☞ \quad -60.0\text{ m} = 0 + (12.50\text{ m/s})t - (4.90\text{ m/s}^2)t^2.$$

Reduce to a quadratic equation: $4.90t^2 - 12.50t - 60.0 = 0$.

Solve for $t = \boxed{5.00\text{ s}}$ or −2.45 s, which is physically meaningless.

(b) $v = v_o - gt = 12.50\text{ m/s} - (9.80\text{ m/s}^2)(5.00\text{ s}) = -36.5\text{ m/s} = \boxed{36.5\text{ m/s}}$ downward.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

72. (a) We take $y_o = 0$. The answer is $\boxed{(1)\ \sqrt{6}}$.

$y = y_o + v_o t - \frac{1}{2}gt^2 = -\frac{1}{2}gt^2$, ☞ $t = \sqrt{-\dfrac{2y}{g}}$. $\dfrac{t_M}{t_E} = \dfrac{\sqrt{1/g_M}}{\sqrt{1/g_E}} = \sqrt{\dfrac{g_E}{g_M}} = \sqrt{6}$.

(b) Given: $v_o = 18.0$ m/s, $v = 0$ ("max height"). Find: y and t.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $y = \dfrac{v_o^2 - v^2}{2g} = \dfrac{v_o^2}{2g}$. So $\dfrac{y_M}{y_E} = \dfrac{g_E}{g_M} = 6$.

For the total trip (up and down), the final position is zero ($y = 0$).

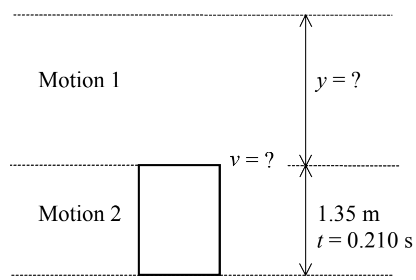
So $y = y_o + v_o t - \frac{1}{2}gt^2 = 0$, ☞ $t = \dfrac{2v_o}{g}$.

Therefore $\dfrac{t_M}{t_E} = \dfrac{g_E}{g_M} = 6$.

On the Earth, $y_E = \dfrac{(18.0\text{ m/s})^2}{2(9.80\text{ m/s}^2)} = \boxed{16.5\text{ m}}$. $t_E = \dfrac{2(18.0\text{ m/s})}{9.80\text{ m/s}^2} = \boxed{3.67\text{ s}}$.

On the Moon, $y_M = 6\, y_E = \boxed{99.2\text{ m}}$. $t_M = 6\, t_E = \boxed{22.0\text{ s}}$.

73. The key to this exercise is to find the velocity of the object when it reaches the top of the window (it is not zero). This velocity is the initial velocity for Motion 1 and the final velocity for Motion 2.



Consider Motion 2 first. Taking $y_o = 0$.

Given: $y = -1.35$ m, $t = 0.210$ s. Find: v_o.

Apply $y = y_o + v_o t - \frac{1}{2}gt^2$,

$v_o = \dfrac{y}{t} + \frac{1}{2}gt = \dfrac{-1.35\text{ m}}{0.210\text{ s}} + (4.90\text{ m/s}^2)(0.210\text{ s}) = -5.40$ m/s.

Now consider Motion 1. Also take $y_o = 0$.

Given: $v_o = 0$, $v = -5.40$ m. Find: y.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $y = \dfrac{v_o^2 - v^2}{2g} = \dfrac{0 - (-5.40\text{ m/s})^2}{2(9.80\text{ m/s}^2)} = 1.49$ m.

So, it is $\boxed{1.49\text{ m above the top of the window}}$.

74. (a) Given: $v_o = 0$, $(y - y_o) = -10.0$ m (downward). Find: v.

$v^2 = v_o^2 - 2g(y - y_o) = -2(9.80\text{ m/s}^2)(-10.0\text{ m}) = 196\text{ m}^2/\text{s}^2$. So $v = -14.0\text{ m/s} = \boxed{14.0\text{ m/s}}$ downward.

(b) Given: $v = 0$ (max height), $(y - y_o) = 4.00$ m. Find: v_o.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $v_o = \sqrt{v^2 + 2g(y - y_o)} = \sqrt{0 + 2(9.80\text{ m/s}^2)(4.00\text{ m})} = \boxed{8.85\text{ m/s}}$.

(c) Falling: $v = v_o - gt$, ☞ $t_1 = \dfrac{v_o - v}{g} = \dfrac{0 - (-14.0\text{ m/s})}{9.80\text{ m/s}^2} = 1.43$ s.

Rising: $t_2 = \dfrac{8.85\text{ m/s} - 0}{9.80\text{ m/s}^2} = 0.90$s.

Therefore the total time is $1.43\text{ s} + 0.903\text{ s} = \boxed{2.33\text{ s}}$.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

75. (a) Given: $v_o = 0$, $a = 12.0\text{ m/s}^2$, $(y - y_o) = 1000\text{ m}$. Find: v.

$v^2 = v_o^2 + 2a(y - y_o) = 0 + 2(12.0\text{ m/s}^2)(1000\text{ m}) = 24\,000\text{ m}^2/\text{s}^2$. So $v = 154.9\text{ m/s} = \boxed{155\text{ m/s}}$.

(b) Given: $v_o = 154.9\text{ m/s}$, $v = 0$ (maximum height). Find: $(y - y_o)$.

$$v^2 = v_o^2 - 2g(y - y_o), \quad ☞ \quad y - y_o = \frac{v_o^2 - v^2}{2g} = \frac{(154.9\text{ m/s})^2 - 0^2}{2(9.80\text{ m/s}^2)} = 1224\text{ m.}$$

So the maximum altitude is $1000\text{ m} + 1224\text{ m} = \boxed{2.22 \times 10^3\text{ m}}$.

(c) Accelerating at 12.0 m/s^2. $v = v_o + a$, ☞ $t_1 = \frac{v - v_o}{a} = \frac{154.\ 9\text{ m/s} - 0}{12.0\text{ m/s}^2} = 12.9\text{ s}$.

Free falling (still going up). $v = v_o - gt$, ☞ $t_2 = \frac{v_o - v}{g} = \frac{154.9\text{ m/s} - 0}{9.80\text{ m/s}^2} = 15.8\text{ s}$.

So the total time is $12.9\text{ s} + 15.8\text{ s} = \boxed{28.7\text{ s}}$.

76. (a) When the rocket has fuel, the motion is *not* a free fall but rather a motion with constant acceleration of $2g$.

Given: $v_o = 0$, $a = 2g$, $t = t$. Find: v, and y (take $y_o = 0$).

$v = v_o + at = 0 + 2gt = \boxed{2gt}$. $y = y_o + v_o t + \frac{1}{2}at^2 = 0 + 0 + \frac{1}{2}(2g)t^2 = \boxed{gt^2}$.

(b) When the fuel runs out, the rocket is moving upward with a speed of $2gt$ and at a height of gt^2. From that point on, the acceleration experienced by the rocket is gravitational acceleration.

Given: $v_o = 2gt$, $v = 0$ (maximum height), $a = -g$, $y_o = gt^2$. Find: y.

$$v^2 = v_o^2 - 2g(y - y_o), \quad ☞ \quad y_{max} = y_o + \frac{v_o^2 - v^2}{2g} = gt^2 + \frac{v_o^2}{2g} = gt^2 + \frac{(2gt)^2}{2g} = gt^2 + 2gt^2 = \boxed{3gt^2}.$$

(c) $y_{max} = 3gt^2 = 3(9.80\text{ m/s}^2)(30.0\text{ s})^2 = \boxed{2.65 \times 10^4\text{ m}}$.

77. (a) Take $x_o = 0$ and use $x = x_o + v_o t + \frac{1}{2}at^2$.

For car: $d = 0 + \frac{1}{2}(3.70\text{ m/s}^2)t^2$. Eq. (1)

For motorcycle: $d + 25.0\text{ m} = 0 + \frac{1}{2}(4.40\text{ m/s}^2)t^2$. Eq. (2)

Eq. (2) − Eq. (1) gives: $25.0\text{ m} = (0.35\text{ m/s}^2)t^2$. Solving, $t = \boxed{8.45\text{ s}}$.

(b) For car: $x_C = \frac{1}{2}(3.70\text{ m/s}^2)(8.45\text{ s})^2 = \boxed{132\text{ m}}$. For motorcycle: $x_M = x_C + 25.0\text{ m} = \boxed{157\text{ m}}$.

(c) During 8.45 s + 2.00 s = 10.45 s, the motorcycle will be ahead of the car by

$\Delta x = x_M - x_C = \frac{1}{2}[(4.40\text{ m/s}^2) - (3.70\text{ m/s}^2)](10.45\text{ s})^2 - 25.0\text{ m} = \boxed{13\text{ m}}$.

78. (a) Jogger A time: $t_A = \frac{d_A}{s_A} = \frac{150\text{ m}}{2.70\text{ m/s}} = 55.56\text{ s}$, jogger B time: $t_A = \frac{\pi r}{s_B} = \frac{\pi(150\text{ m})/2}{2.70\text{ m/s}} = 87.22\text{ s}$.

So jogger A will arrive before jogger B by $87.22\text{ s} - 55.56\text{ s} = \boxed{32.7\text{ s}}$.

(b) $d_B = \pi(150\text{ m})/2 = 236\text{ m} > d_A = 100\text{ m}$.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

(c) Their displacements are the same. Both are $\Delta x = \boxed{150 \text{ m north}}$.

(d) $\bar{v}_A = \dfrac{\Delta x}{\Delta t} = \dfrac{150 \text{ m north}}{55.56 \text{ s}} = \boxed{2.70 \text{ m/s north}}$. $\bar{v}_B = \dfrac{150 \text{ m north}}{87.22 \text{ s}} = \boxed{1.72 \text{ m/s north}}$

79. (a) Given: $a = -2.50 \text{ m/s}^2$, $x = 300$ m (taking $x_o = 0$), $v = 0$ (come to rest). Find: v_o.

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $v_o = \sqrt{-2a(x - x_o)} = \sqrt{-2(-2.50 \text{ m/s}^2)(300 \text{ m})} = \boxed{38.7 \text{ m/s}}$.

(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{0 - 38.7 \text{ m/s}}{-2.50 \text{ m/s}^2} = \boxed{15.5 \text{ s}}$.

(c) $v_o = 38.7 \text{ m/s} + 4.47 \text{ m/s} = 43.2 \text{ m/s}$.

$v^2 = v_o^2 + 2a(x - x_o) = (43.2 \text{ m/s})^2 + 2(-2.50 \text{ m/s}^2)(300 \text{ m}) = 366.2 \text{ m}^2/\text{s}^2$. So $v = \boxed{19.2 \text{ m/s}}$.

80. The height of each floor is $\dfrac{509 \text{ m}}{101} = 5.040$ m. The height for 89 floors is then 89(5.040 m) = 448.6 m. At midpoint, the height is 224.3 m. 1008 m/min = 16.8 m/s and 610 m/min = 10.2 m/s.

(a) Up. $x = 224.3$ m (taking $x_o = 0$), $v_o = 0$, $v = 16.8$ m/s. Find: a.

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $a_{\text{up}} = \dfrac{v^2 - v_o^2}{2x} = \dfrac{(16.8 \text{ m/s})^2 - 0}{2(224.3 \text{ m})} = \boxed{0.629 \text{ m/s}^2}$.

Down. $x = 224.3$ m (taking $x_o = 0$), $v_o = 0$, $v = 10.2$ m/s. Find: a.

$a_{\text{down}} = \dfrac{v^2 - v_o^2}{2x} = \dfrac{(10.2 \text{ m/s})^2 - 0}{2(224.3 \text{ m})} = \boxed{0.232 \text{ m/s}^2}$.

(b) $v = v_o + at$, ☞ $t_{\text{up}} = \dfrac{v - v_o}{a} = \dfrac{16.8 \text{ m/s} - 0}{0.629 \text{ m/s}^2} = 26.70$ s.

However this is the time to accelerate to the peak speed. After that, the elevator needs to slow down to zero. So the total upward time is twice or 53.4 s. $t_{\text{down}} = \dfrac{10.2 \text{ m/s} - 0}{0.232 \text{ m/s}^2} = 43.97$ s.

Similarly, the total downward time is 87.94 s. The time difference is 87.94 s – 53.4 s = $\boxed{34.5 \text{ s}}$.

81. (a) Assume Lois falls a distance of d (taking $y_o = 0$), then Superman will move up a distance of (300 m – d). Also assume he catches her t seconds after she was dropped. The initial velocity for both Lois and Superman is zero.

For Lois: $y = -d = y_o + v_o t - \frac{1}{2} g t^2 = 0 + 0 - \frac{1}{2}(9.80 \text{ m/s}^2)t^2 = -(4.90 \text{ m/s}^2)t^2$.

For Superman: $(300 \text{ m} - d) = 0 + \frac{1}{2}(15 \text{ m/s}^2)t^2 = (7.50 \text{ m/s}^2)t^2$.

Therefore, $\dfrac{300 \text{ m} - d}{7.50 \text{ m/s}^2} = \dfrac{d}{4.90 \text{ m/s}^2}$. Or $300 \text{ m} - d = \dfrac{7.50 \text{ m/s}^2}{4.90 \text{ m/s}^2} d = 1.53d$.

So $d = \dfrac{300 \text{ m}}{2.53} = 118.6 \text{ m} = \boxed{119 \text{ m}}$.

(b) $d = -118.6 \text{ m} = -(4.90 \text{ m/s}^2)t^2$, ☞ $t = \boxed{4.92 \text{ s}}$.

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

(c) Lois: $v = v_o - gt = 0 - (9.80\ \text{m/s}^2)(4.92\ \text{s}) = -\boxed{48.2\ \text{m/s}} \approx 107$ mi/h.

Superman: $v = 0 + (15\ \text{m/s}^2)(4.92\ \text{s}) = \boxed{73.8\ \text{m/s}} \approx 165$ mi/h. These speeds are quite high.

82. (a) Given: $a = -9.00\ \text{m/s}^2$, $v_o = 45.0$ m/s, $v = 0$ (brake to a stop). Find: t.

$$v = v_o + at, \quad ☞ \quad t = \frac{v - v_o}{a} = \frac{0 - 45.0\ \text{m/s}}{-9.00\ \text{m/s}^2} = \boxed{5.00\ \text{s}}.$$

(b) $x - x_o = v_o t + \frac{1}{2} a t^2 = (45.0\ \text{m/s})(5.00\ \text{s}) + \frac{1}{2}(-9.00\ \text{m/s}^2)(5.00\text{s})^2 = \boxed{113\ \text{m}}$.

(c) The time in acceleration is 15.0 s − 5.00 s = 10.0 s. $v_o = 0$, and $v = 45.0$ m/s.

$$a = \frac{v - v_o}{t} = \frac{45.0\ \text{m/s} - 0}{10.0\ \text{s}} = \boxed{4.50\ \text{m/s}^2}.$$

(d) $x - x_o = 0 + \frac{1}{2}(4.50\ \text{m/s}^2)(10.0\text{s})^2 = \boxed{225\ \text{m}}$.

83. (a) Given: $v_o = -200$ m/s, $g = 3.00\ \text{m/s}^2$, $y = -8000$ m (taking $x_o = 0$). Find: v.

$$v^2 = v_o^2 - 2g(y - y_o) = (-200\ \text{m/s})^2 - 2(3.00\ \text{m/s}^2)(-8000\ \text{m}) = 8.80 \times 10^3\ \text{m}^2/\text{s}^2$$

So $v = \boxed{-297\ \text{m/s}}$. The negative sign indicates that the Lander is moving downward.

(b) $v_o = -297$ m/s, $v = -20.0$ m/s, $y = -12\,000$ m. Find: a.

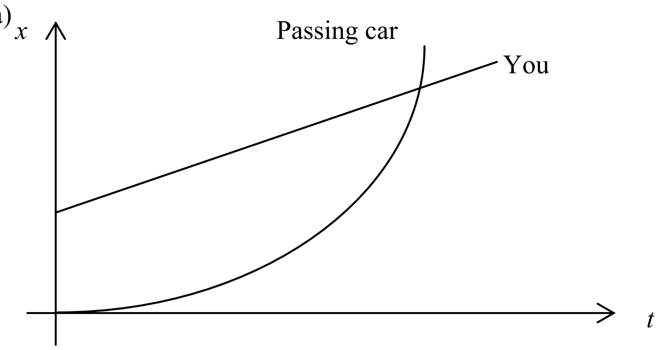
$$v^2 = v_o^2 + 2a(y - y_o), \quad ☞ \quad a = \frac{v^2 - v_o^2}{2(y - y_o)} = \frac{(-20.0\ \text{m/s})^2 - (-297\ \text{m/s})^2}{2(-12\,000\ \text{m})} = \boxed{3.66\ \text{m/s}^2}.$$

$$\text{(c) } v = v_o - gt, \quad ☞ \quad t_1 = \frac{v_o - v}{g} = \frac{-200\ \text{m/s} - (-297\ \text{m/s})}{3.00\ \text{m/s}^2} = 32.3\ \text{s}.$$

$$v = v_o + at, \quad ☞ \quad t_2 = \frac{v - v_o}{a} = \frac{-20.0\ \text{m/s} - (-297\ \text{m/s})}{3.66\ \text{m/s}^2} = 75.7\ \text{s}.$$

So the total time is 32.3 s + 75.7 s = $\boxed{108\ \text{s}}$.

84. (a)



(b) Convert units: 25.0 mi/h = 11.175 m/s.

During the 7.00 s, the distance you travel at a constant 25.0 mi/h (11.175 m/s) is

$x_{you} = vt = (11.175\ \text{m/s})(7.00\ \text{s}) = 78.225$ m

The passing car travels this distance plus 90.0 m with constant acceleration from an initial speed of 11.175 m/s.

Therefore we have

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$x_{passer} = v_0 t + ½ at^2$

78.225 m + 90.0 m = (11.175 m/s)(7.00 s) + ½ a(7.00 s)^2

a = $\boxed{3.67 \text{ m/s}^2}$

(c) As shown in part (b), you traveled $\boxed{78.2 \text{ m}}$. The passing car traveled 90.0 m farther, for a distance of $\boxed{168 \text{ m}}$.

(d) $v = v_0 + at$ = 11.175 m/s + (3.67 m/s^2)(7.00 s) = $\boxed{36.9 \text{ m/s or } 82.5 \text{ mi/h}}$

85. Convert units: 70 mi/h = 31.29 m/s.

First find the speed with which she encounters the ice:

$v^2 = v_0^2 + 2a(x - x_0)$ = (31.29 m/s)^2 + 2(–7.50 m/s^2)(50 m)

v = 15.135 m/s

Now look at her deceleration on the ice using the same equation:

0 = (15.135 m/s)^2 + 2a(80 m)

a = $\boxed{-1.43 \text{ m/s}^2}$

86. (a) $v^2 = v_0^2 + 2a(x - x_0)$ = 0 + 2(4.00 m/s^2)(45.0 m)

v = $\boxed{19.0 \text{ m/s}}$

(b) The same formula as in part (a) gives

0 = (19.0 m/s)^2 + 2a(20 m)

a = $\boxed{-9.00 \text{ m/s}^2}$, deceleration

(c) $v = v_0 + at$

0 = 19.0 m/s + (–9.00 m/s^2)t

t = $\boxed{2.11 \text{ s}}$

(d) Using the same formula as in part (a), we have

v^2 = (19.0 m/s)^2 + 2(–9.00 m/s^2)(10 m)

v = $\boxed{13.4 \text{ m/s}}$

87. (a) First find the rocket's speed just as its engines stop:

$v^2 = v_0^2 + 2a(x - x_0)$ = 0 + 2(30 m/s^2)(1000 m) = 244.95 m/s

Now find the maximum height it reaches above the point where the engines stop:

$v^2 = v_0^2 + 2a(x - x_0)$

0 = (244.95 m/s)^2 + 2(–9.80 m/s^2)x

x = 3061.2 m

The maximum height is therefore

x_{max} = 3061.2 m + 1000 m = 4061.2 m = $\boxed{4060 \text{ m}}$

(b) First find the time t_1 to reach a height of 1000 m:

$x = v_0 t + ½ at^2$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

$1000 \text{ m} = 0 + \frac{1}{2}(30 \text{ m/s}^2)t_1^2$

$t_1 = 8.165 \text{ s}$

Now find the additional time t_2 to reach the maximum height:

$v = v_0 + at$

$0 = 244.95 \text{ m/s} - (9.80 \text{ m/s}^2)t_2$

$t_2 = 24.99 \text{ s}$

The total time t is the sum of these two times:

$t = t_1 + t_2 = 8.165 \text{ s} + 24.99 \text{ s} = \boxed{33.2 \text{ s}}$

(c) After falling for 0.500 s, the rocket's downward speed is

$v = gt = (9.80 \text{ m/s}^2)(0.500 \text{ s}) = 4.90 \text{ m/s}$

During that time it fell a distance of

$x = \frac{1}{2}gt^2 = \frac{1}{2}(9.80 \text{ m/s}^2)(0.500 \text{ s})^2 = 1.225 \text{ m}$

The distance it must fall at a constant speed of 4.90 m/s is

$4061.2 \text{ m} - 1.225 \text{ m} = 4060 \text{ m}$

The time to fall this distance is

$t = x/v = (4060 \text{ m})/(4.90 \text{ m/s}) = 828.6 \text{ s}$

The total time the rocket is in the air is

$t_{total} = t_{up} + t_{down} = 33.2 \text{ s} + 0.500 \text{ s} + 828.6 \text{ s} = \boxed{862 \text{ s}}$

88. (a) The acceleration is $\boxed{\text{upward}}$ because the ball reverses its initial downward velocity.

(b) First find the ball's velocity v_1 just before it hits the floor:

$v_1^2 = v_0^2 + 2a(x - x_0) = 0 + 2(9.80 \text{ m/s}^2)(2.5 \text{ m})$

$v_1 = 7.00 \text{ m/s}$ (downward)

Now find the ball's velocity v_2 just as it starts upward after bouncing off the floor:

$v^2 = v_0^2 + 2a(x - x_0)$

$0 = v_2^2 + 2(-9.80 \text{ m/s}^2)(2.1 \text{ m})$

$v_2 = 6.4156 \text{ m/s}$ (upward)

Calling upward positive, the ball's acceleration is therefore

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t} = \frac{6.4156 \text{ m/s} - (-7.00 \text{ m/s})}{0.00070 \text{ s}} = \boxed{1.9 \times 10^4 \text{ m/s}}$$

Copyright © 2010 Pearson Education, Inc. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.