Even answers, Chapter 2

2.2. (a) -4.42 m/s
(b) The average velocity is zero.

2.4 (a) 4.4 m/s .
(b) -0.73 m/s . The average velocity is directed westward.

2.6. (a) 286 s , (1770 m and 1570 m .
(b) 572 s . 3540 m. 17 full laps for 3400 m and 140 m past the starting line in this 18^{th} lap.

2.8 **(a)** $+2.80$ m/s
(b) $+5.20$ m/s
(c) $+7.60$ m/s

2.10. **(a)** The velocity is zero where the graph is horizontal; point IV.
(b) The velocity is constant and positive where the graph is a straight line with positive slope; point I.
(c) The velocity is constant and negative where the graph is a straight line with negative slope; point V.
(d) The slope is positive and increasing at point II.
(e) The slope is positive and decreasing at point III.

2.12. **(a)** 0 s to 2 s: $a_{\text{av},x} = 0$; 2 s to 4 s: $a_{\text{av},x} = 1.0 \text{ m/s}^2$; 4 s to 6 s: $a_{\text{av},x} = 1.5 \text{ m/s}^2$; 6 s to 8 s: $a_{\text{av},x} = 2.5 \text{ m/s}^2$; 8 s to 10 s: $a_{\text{av},x} = 2.5 \text{ m/s}^2$; 10 s to 12 s: $a_{\text{av},x} = 2.5 \text{ m/s}^2$; 12 s to 14 s: $a_{\text{av},x} = 1.0 \text{ m/s}^2$; 14 s to 16 s: $a_{\text{av},x} = 0$. The acceleration is not constant over the entire 16 s time interval. The acceleration is constant between 6 s and 12 s.

2.14 **(a)** (i) 1.7 m/s^2. (ii) -1.7 m/s^2. (iii) 0. (iv) 0.
(b) At $t = 20$ s , $a_x = 0$. At $t = 35$ s , $a_x = a_{\text{av-}x} = -1.7 \text{ m/s}^2$.

2.16 **a)** -1.0 m/s^2
(b) -1.0 m/s^2
(c) -3.0 m/s^2

2.18. **(a)** 0.500 m/s^2
(b) At $t = 0$, $a_x = 0$. At $t = 5.00$ s , $a_x = 1.00 \text{ m/s}^2$.

2.20. $x = 15.0$ m and $a_x = -38.4 \text{ m/s}^2$.

2.24. **(a)** 2440 m/s^2.
(b) 1.10 m

2.26 **(a)** 1.67 m/s^2.
(b) 12 s

(c) $240\ \text{m}$.

2.28. **(a)** $-26.5\ \text{ft/s}^2$,
(b) $90.5\ \text{mph}$
(c) $3.32\ \text{s}$

2.32. When a_x is constant, the graph of v_x versus *t* is a straight line and the graph of *x* versus *t* is a parabola. When $a_x = 0$, v_x is constant and *x* versus *t* is a straight line.

2.36. **(a)** 250 m.
(b) At $t = 12.5\ \text{s}$, $40\ \text{m/s}$.

2.38. **(a)**, $60\ \text{m/s} = 200\ \text{km/h} = 140\ \text{mi/h}$.
(b) Raindrops actually have a speed of about 1 m/s as they strike the ground.
(c) The actual speed at the ground is much less than the speed calculated assuming free-fall, so neglect of air resistance is a very poor approximation for falling raindrops.

2.40. $4.1\ \text{m/s}$.
The same descent on earth would result in a final speed of 9.9 m/s, since the acceleration due to gravity on earth is much larger than on the moon.

2.42. **(a)** 30.6 m.
(b) $24.5\ \text{m/s}$

2.44. **(a)** The sandbag is 40.1 m above the ground. $v_y = -4.80\ \text{m/s}$.
(b) $3.41\ \text{s}$.
(c) $-28.4\ \text{m/s}$
(d) $y - y_0 = 1.28\ \text{m}$. The maximum height is 41.3 m above the ground.

2.46. **(a)** $+14.5\ \text{m/s}$.
(b) $y - y_0 = 10.7\ \text{m}$.
(c) At the maximum height $v_y = 0$.
(d) The acceleration is constant and equal to $9.80\ \text{m/s}^2$, downward, at all points in the motion, including at the maximum height.

2.48. **(a)** $+2.04\ \text{s}$.
(b) $v_y = -20.0\ \text{m/s}$. $t = +6.12\ \text{s}$.
(c) $t = 0$ and $t = +8.16\ \text{s}$.
(d) $4.08\ \text{s}$.
(e) The acceleration is $9.80\ \text{m/s}^2$, downward, at all points in the motion.

2.50. $t = 2.0\ \text{s}$, $v_x = 6.8\ \text{m/s}$.
(b) $t = 1.0\ \text{s}$ $x_0 = 1.4\ \text{m}$. $t = 2.0\ \text{s}$, $x = 11.8\ \text{m}$.

(c) $x(t) = 1.4\text{ m} + (4.4\text{ m/s})t + (0.20\text{ m/s}^3)t^3$. $v_x(t) = 4.4\text{ m/s} + (0.60\text{ m/s}^3)t^2$.
$a_x(t) = (1.20\text{m/s}^3)t$.

2.52. **(a)** Slope $= a = 0$ for $t \geq 1.3\text{ ms}$.
(b) $\approx 0.25\text{ cm}$
(c) $a(0.5\text{ ms}) \approx a(1.0\text{ ms}) \approx 1.0\times10^5\text{ cm/s}^2$,
(d) $h(0.5\text{ ms}) \approx 8.3\times10^{-3}\text{ cm}$.
$h(1.0\text{ ms}) \approx 5.0\times10^{-2}\text{ cm}$.
$h(1.5\text{ ms}) \approx 0.11\text{ cm}$

2.54. **(a)** 2.7 mi/h.
(b) 24 mi/h.
(c) No

2.56. **(a)** 1.25 m/s.
(b) 1.67 m/s.
(c) 0
(d) T 1.43 m/s.

2.58. **(a)** 35.4 m.
(b) Th 7000 vehicles/h.

2.60. **(a)** 5.60 m/s. 7.20 m/s. 8.80 m/s.
(b) 0.80 m/s^2.
(c) 4.80 m/s.
(d 6.0 s.
(e) 57.6 m.

2.62. **(a)** $9.5\times10^{15}\text{ m}$
(b) 0.30 m
(c) $500\text{ s} = 8.33\text{ min}$
(d) 2.6 s
(e) $16{,}100\text{ s} = 4.5\text{ h}$

2.64. **(a)** 225.0 m.
(b) The total displacement is -75.0 m. The ball ends up 75.0 m in the negative *x*-direction from where it started.

(d) The ball is in contact with the floor for a small but nonzero period of time and the direction of the velocity doesn't change instantaneously. So, no, the actual graph of $v_x(t)$ is not really vertical at 5.00 s.

2.66. **(a) Yes**
(b) 537 m. The passenger train moves 537 m before the collision. The freight train moves 337 m.

2.68. 150 m .
(NOTE: The grasshopper ends up 100 m from where it started, so the magnitude of his final displacement is 100 m.)

2.70 **(a)** $t = \frac{1}{a_x}\left(-v_0 \pm \sqrt{v_0^2 + 2a_x D}\right)$. Only the positive root is physical,

so $t = \frac{1}{a_x}\left(-v_0 + \sqrt{v_0^2 + 2a_x D}\right)$.

(b) $v_1 = a_x t = \sqrt{v_0^2 + 2a_x D} - v_0$

2.74. **(a)** $x(t) = \alpha t - \frac{1}{3}\beta t^3 = (4.00 \text{ m/s})t - (0.667 \text{ m/s}^3)t^3$. $a_x(t) = \frac{dv_x}{dt} = -2\beta t = -(4.00 \text{ m/s}^3)t$.

(b) 3.77 m .

2.76 Release the egg when your professor is 3.60 m from the point directly below you.

2.78. **(a)** 21.6 m/s .
(b) 23.8 m

2.80. The top of the window is 0.310 m below the windowsill.

2.82 **(a)** 1990 m .
(b) 33.7 s after the second stage fires.
(c) The rocket has speed 198 m/s as it reaches the launch pad.

2.84. **(a)**. 532 m
(b) 102 m/s .

2.86. **(a** 378 m
(b) 184 m

2.88. **(a)**. 384 m .
(b) You would have calculated $d = 490$ m . You would have overestimated the height of the cliff. It actually takes the rock less time than 10.0 s to fall to the ground.

2.90. **(a)** 165 m/s .
(c) The skyscraper must be at least 122 m high.

2.92 **(a)** $t = \frac{H}{v_0}$.

(b) $H = \frac{v_0^2}{g}$.

2.94. **(a)** $\sqrt{2gH}$

(b) Motion from $y_0 = h$ to $y = 0$: $y - y_0 = -h$, $v_{0y} = -\sqrt{2gH}$. $v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$ gives The acceleration of the apple while it is in the grass is gH/h, upward.

(c) Graphs of y-t, v_y-t and a_y-t are sketched in Figure 2.94.

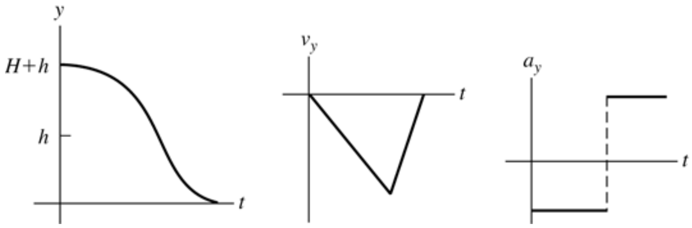

Figure 2.94

2.96. $\dfrac{t_1}{t_2} = 2.4$.

The person spends over twice as long above $y_{max}/2$ as below $y_{max}/2$. The average speed is less above $y_{max}/2$ than it is when he is below this height.

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2.98. **(a)** 246 m.

(b) The above method assumed that $t > 0$ when the square root was taken. The negative root (with $\Delta t = 0$) gives an answer of 2.51 m, clearly not a "cliff". This would correspond to an object that was initially near the bottom of this "cliff" being thrown upward and taking 1.30 s to rise to the top and fall to the bottom. Although physically possible, the conditions of the problem preclude this answer.