Solutions to Final Review Guide problems chapters 2-7.

Kinematics in one dimension: Chapter 2.

2 problems: see problems 22, 28, 31, 34 on pages 95-96 in the text.

22. *A bullet in a gun is accelerated from the firing chamber to the end of the barrel at an average rate of* $6.20\times10^5\ \text{m/s}^2$ *for* $8.10\times10^{-4}\ \text{s}$*. What is its muzzle velocity (that is, its final velocity)?*

Solution

$$v = v_0 + at = 0\ \text{m/s} + (6.20\times10^5\ \text{m/s}^2)(8.10\times10^{-4}\ \text{s}) = \underline{502\ \text{m/s}}$$

…

28. *A powerful motorcycle can accelerate from rest to 26.8 m/s (100 km/h) in only 3.90 s. (a) What is its average acceleration? (b) How far does it travel in that time?*

Solution

(a) $$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{26.8\ \text{m/s} - 0\ \text{m/s}}{3.90\ \text{s}} = \underline{6.87\ \text{m/s}^2}$$

(b) $$x - x_0 = \frac{1}{2}(v_0 + v)t = \frac{1}{2}(0\ \text{m/s} + 26.8\ \text{m/s})(3.90\ \text{s}) = \underline{52.3\ \text{m}}$$

31. *A swan on a lake gets airborne by flapping its wings..*

Solution

(a) $$x - x_0 = \frac{v^2 - v_0^2}{2a} = \frac{(6.00\ \text{m/s})^2 - (0\ \text{m/s})^2}{2(0.350\ \text{m/s}^2)} = \underline{51.4\ \text{m}}$$

(b) $$t = \frac{v - v_0}{a} = \frac{6.00\ \text{m/s} - 0\ \text{m/s}}{0.350\ \text{m/s}^2} = \underline{17.1\ \text{s}}$$

34. *In World War II, there were several reported cases of airmen ..*

Solution

Knowns: $x = 3\ \text{m};\ v = 0\ \text{m/s};\ v_0 = 54\ \text{m/s}$

We want a*, so we can use this equation:*

$$v^2 = v_0^2 + 2ax \Rightarrow a = \frac{v^2 - v_0^2}{2x} = \frac{0\ \text{m/s} - (54\ \text{m/s})^2}{2(3\ \text{m})} = \underline{-486\ \text{m/s}^2}$$

. Negative acceleration means that the pilot was decelerating at a rate of 486 m/s every second.

Kinematics to two dimensions. Free fall. Chapter 3

<u>2 problems see problems; 25, 29, 38, 40, 46 (on pages 145-146 in the text.)</u>

25. *A projectile is launched at ground level with an initial speed of 50.0 m/s ..*

Solution

Range of projectile on level ground: $R = \frac{v_0^2}{g}\sin 2\theta = \frac{(50.0\text{ m/s})^2}{9.80\text{ m/s}^2}\sin 60.0° = 221\text{ m}$

The time in air is given as 3.00 s, so projectile landed above level ground. Find the position relative to the launching point:

$$x = v_{0x}t = (50.0\text{ m/s})(\cos 30.0°)(3.00\text{ s}) = 1.30\times 10^2\text{ m}$$

$$y = v_{0y}t + \frac{1}{2}at^2 = (50.0\text{ m/s})(\sin 30.0°)(3.00\text{ s}) - \frac{1}{2}(9.80\text{ m/s}^2)(3.00\text{ s})^2 = 30.9\text{ m}$$

Therefore, the projectile landed $1.30\times 10^2\text{ m}$ horizontally and 30.9 m vertically from the launching point.

29. *An archer shoots an arrow at a 75.0 m distant target; ..*

Solution

(a) $R = 75.0\text{ m}, v_0 = 35.0\text{ m/s}, \theta = ?$

Use the equation for a projectile on level ground: $R = \frac{v_0^{\,2}\sin 2\theta_0}{g}$

$$\theta_0 = \frac{1}{2}\sin^{-1}\left(\frac{gR}{v_0^{\,2}}\right) = \frac{1}{2}\sin^{-1}\left[\frac{(9.80\text{ m/s}^2)(75.0\text{ m})}{(35.0\text{ m/s})^2}\right] = \underline{18.4°}$$

(b) The arrow will be at the tree when the vertical velocity is zero:

$$v_y = v_0\sin\theta - gt \Rightarrow t = v_0\sin\theta / g = 1.127\text{ s}$$

$$y = v_0\sin\theta t - \frac{1}{2}gt^2$$

$$= (35.0\text{ m/s})\sin 18.4°(1.13\text{ s}) - \frac{1}{2}(9.80\text{ m/s}^2)(1.13\text{ s})^2 = \underline{6.23\text{ m}}$$

The arrow goes over the branch!

38. A football quarterback is moving straight backward at a speed of 2.00 m/s ..

Solution (a) Note: the player's backward motion will not be a factor in this problem.

α = angle relative to ground

$$R = \frac{v_0^2 \sin 2\alpha}{g} \Rightarrow v_0 = \sqrt{\frac{Rg}{\sin 2\alpha}} = \sqrt{\frac{(18.0\text{ m})(9.80\text{ m/s}^2)}{\sin 50.0°}} = \underline{15.2\text{ m/s}}$$

$$v_x = v_0 \cos\alpha = (15.2\text{ m/s})\cos 25.0° = 13.8\text{ m/s}$$

(b) $$t = \frac{R}{v_x} = \frac{18.0\text{ m}}{13.8\text{ m/s}} = \underline{1.31\text{ s}}$$

(c) $$h = \frac{(v_0 \sin\alpha)^2}{2g} = \frac{[(15.2\text{ m/s})(\sin 25.0°)]^2}{2(9.80\text{ m/s}^2)} = \underline{2.11\text{ m}}$$

40. *An eagle is flying horizontally at a speed of 3.00 m/s when the fish in her talons wiggles loose and falls into the lake 5.00 m below. Calculate the velocity of the fish relative to the water when it hits the water.*

Solution

x-direction (horizontal); given:

$$v_{0x} = 3.00\text{ m/s}, a_x = 0\text{ m/s}^2, v_x = v_{0x} = \text{constant} = 3.00\text{ m/s}$$

y-direction (vertical); given:

$$v_{0y} = 0.00\text{ m/s}, a_y = -g = -9.80\text{ m/s}^2, (y - y_0) = -5.00\text{ m}$$

$$v_y^2 = v_{0y}^2 - 2g(y - y_0)$$

$$v_y = \sqrt{(0\text{ m/s})^2 - 2(9.80\text{ m/s}^2)(-5.00\text{ m})} = -9.90\text{ m/s}$$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(3.00\text{ m/s})^2 + (-9.90\text{ m/s})^2} = 10.3\text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{-9.90\text{ m/s}}{3.00\text{ m/s}}\right) = -73.1°$$

$$\mathbf{v} = \underline{10.3\text{ m/s}, 73.1° \text{ below the horizontal}}$$

46. A basketball player is running at 5.00 m/s directly toward the basket

(a) Given:

$v_x = 5.00\text{ m/s}$, $y - y_0 = 0.75\text{ m}$, $v_y = 0\text{ m/s}$, $a_y = -g = -9.80\text{ m/s}^2$. Find $v_{0,y}$.

$$v_y^2 = v_{0,y}^2 - 2g(y - y_0)$$

$$v_{0,y} = \sqrt{v_y^2 = 2g(y - y_0)} = \sqrt{(0\text{ m/s})^2 + 2(9.80\text{ m/s}^2)(0.75\text{ m})} = \underline{3.83\text{ m/s}}$$

$v_y = v_{0,y} - gt$ so that

$$t = \frac{v_{0,y} - v_y}{g} = \frac{(3.83\text{ m/s}) - (0\text{ m/s})}{9.80\text{ m/s}^2} = 0.391\text{ s}$$

(b) $x = x_0 + v_x t$, so that $(x - x_0) = v_x t = (5.00\text{ m/s})(0.391\text{ s}) = \underline{1.96\text{ m}}$

Newton's laws.. Chapter 4 and 5. (note: coefficient of friction are described on pages 210-211)

2 problems see problems: chpt. 4: 11, 18, 20, 26, 32, 46, 49 (pgs 197-202 in text)

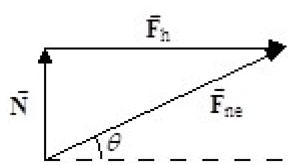
11. *The rocket sled shown in Figure 4.32 accelerates at a rate of* 49.0 m/s^2 *. .*

Solution $F_\text{h} = ma = (75.0\text{ kg})(49.0\text{ m/s}^2) = \underline{3.68 \times 10^3\text{ N}}$ and

$$w = mg = (75.0\text{ kg})(9.80\text{ m/s}^2) = 7.35 \times 10^2\text{ N}$$

(a) $\frac{F_\text{h}}{w} = \frac{ma}{mg} = \frac{a}{g} = \frac{49.0\text{ m/s}^2}{9.80\text{ m/s}^2} = \underline{5.00\text{ times greater than weight}}$

(b)



$$\text{net } F = [(F_\text{h})^2 + (N)^2]^{1/2}$$

$$\text{net } F = [(3675\text{ N})^2 + (735\text{ N})^2]^{1/2} = \underline{3750\text{ N}}$$

$$\theta = \tan^{-1}\left(\frac{N}{F_\text{h}}\right) = \underline{11.3° \text{ from horizontal}}$$

18. What force does a trampoline have to apply to a 45.0-kg gymnast to accelerate

Solution $\text{net } F = +F_\text{t} - mg = ma \Rightarrow F_\text{t} = m(a + g) = (45.0\text{ kg})(7.50\text{ m/s}^2 + 9.80\text{ m/s}^2) = \underline{779\text{ N}}$

20. *Suppose a 60.0-kg gymnast climbs a rope. (a) What is the tension in the rope if they climb at a constant speed? (b) What is the tension in the rope if they accelerate upward at a rate of* $1.50\ \text{m/s}^2$ *?*

Solution

$$\text{net } F = T - mg = ma = 0\ (a = 0 \text{ if constant speed})$$

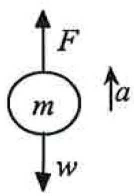
(a) $T = mg = (60.0\,\text{kg})(9.80\,\text{m/s}^2) = \underline{588\,\text{N}}$

$$\text{net } F = T - mg = ma$$

(b) $T = m(g + a) = (60.0\ \text{kg})(9.80\ \text{m/s}^2 + 1.50\ \text{m/s}^2) = \underline{678\ \text{N}}$

26. When landing after a spectacular somersault, a 40.0-kg gymnast ..

Solution



Using the free body diagram:

$\text{net } F = F - W = F - mg = ma$, where $a = 7.00g$ and $m = 40.0\text{kg}$.

Solving for the force gives $F = ma + mg = m(a + g) = m(7.00\,\text{g} + \text{g})$ and substituting in the values gives $F = (40.0\,\text{kg})(8.00 \times 9.80\,\text{m/s}^2) = \underline{3.14 \times 10^3\,\text{N}}$

32. Suppose your car was mired deeply in the mud ..

Solution (a) Use Figure 4.37 as the free body diagram.

$$\text{net } F_x = T\cos\theta - T\cos\theta = 0$$
$$\text{net } F_y = F_\perp - T\sin\theta - T\sin\theta = 0$$
$$F_\perp = 2T\sin\theta = 2(12{,}000\ \text{N})(\sin 2.00°) = 837.6\ \text{N} = \underline{838\ \text{N}}$$

(b) $T = \dfrac{F_\perp}{2\sin\theta} = \dfrac{837.6\ \text{N}}{2\sin 7.00°} = \underline{3.44 \times 10^3\ \text{N}}$

46. A basketball player jumps straight up for a ball. .

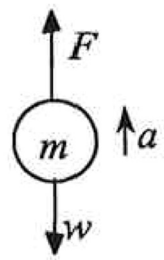
Solution

$v^2 = v_0^2 - 2g(y - y_0)$, where $y - y_0 = 0.900\text{ m}$, and $v = 0\text{ m/s}$.

(a) $v_0 = [2g(y - y_0)]^{1/2} = [2(9.80\text{ m/s}^2)(0.900\text{ m})]^{1/2} = \underline{4.20\text{ m/s}}$

$v^2 = v_0^2 + 2a(y - y_0)$, where $y - y_0 = 0.300\text{ m}$, and $v_0 = 0\text{ m/s}$

(b) $a = \dfrac{v^2}{2(y - y_0)} = \dfrac{(4.20\text{ m/s})^2}{(2)(0.300\text{ m})} = \underline{29.4\text{ m/s}^2}$

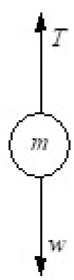
(c) 

net $F = ma = F - w = F - mg$

$F = ma + mg = m(a + g) = 110\text{ kg}(29.4\text{ m/s}^2 + 9.80\text{ m/s}^2) = \underline{4.31\times10^3\text{ N}}$

49. Integrated Concepts An elevator filled with passengers ..

Solution

(a) 

net $F = ma = T - w = T - mg,\ m = 1700\text{ kg}$.

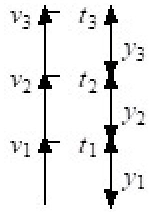
$a = 1.20\text{ m/s}^2$, so the tension is :

$T = m(a + g) = (1700\text{ kg})(1.20\text{ m/s}^2 + 9.80\text{ m/s}^2) = \underline{1.87\times10^4\text{ N}}$

(b) $a = 0\text{ m/s}^2$, so the tension is: $T = w = mg(1700\text{ kg})(9.80\text{ m/s}^2) = \underline{1.67\times10^4\text{ N}}$

$a = 0.600\text{ m/s}^2$, but down :

(c) $T = m(g - a) = (1700\text{ kg})(9.80\text{m/s}^2 - 0.600\text{m/s}^2) = \underline{1.56\times10^4\text{ N}}$

(d) 

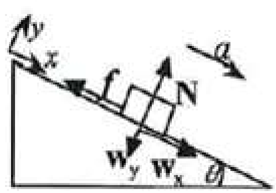
$$y_1 = \frac{1}{2}a_1 t_1^2 = \frac{1}{2}(1.20\text{ m/s}^2)(1.50\text{ s})^2 = 1.35\text{ m and}$$
$$v_1 = a_1 t_1 = (1.20\text{ m/s}^2)(1.50) = 1.80\text{ m/s}$$
$$y_2 = v_1 t_2 = (1.80\text{ m/s})(8.50\text{ s}) = 15.3\text{ m}$$
$$y_3 = v_2 t + a_3 t_3^2 = (1.80\text{ m/s})(3.00\text{ s}) + 0.5(-0.600\text{ m/s})(3.00\text{ s})^2 = 2.70\text{ m}$$
$$v_3 = v_2 + a_3 t_3 = 1.80\text{ m/s} + (-0.600\text{ m/s}^2)(3.00\text{ s}) = 0\text{ m/s}$$

$$y_1 + y_2 + y_3 = 1.35\text{ m} + 15.3\text{ m} + 2.70\text{ m} = 19.35\text{ m} = \underline{19.4\text{ m}}\text{ and } v_{\text{final}} = 0\text{ m/s}$$

chpt 5: Further Applications of Newton's laws. See probs: 9, 10, 17,

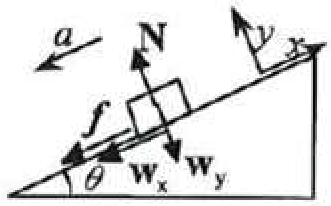
9. *Show that the acceleration of any object down an incline ..*

Solution
$$\text{net } F_y = N - w_y = 0 \Rightarrow N = w_y = mg\cos\theta$$
$$\text{net } F_x = w_x - f = mg\sin\theta - \mu_k mg\cos\theta = ma$$
$$a = \frac{mg\sin\theta - \mu_k mg\cos\theta}{m} = \underline{g(\sin\theta - \mu_k\cos\theta)}$$



10. Calculate the deceleration of a snow boarder going up a $5.0°$ slope ..

Solution



Using the free body diagram:

$\text{net } F_x = w_x + f = ma$ and $\text{net } F_y = N - w_y = 0$ where $w = mg$.

Given $\theta = 5°$ and $\mu_k = 0.100$ (from Table 5.1). Find: a.

Using trigonometry gives $w_x = w \sin\theta$. Also, we know $f = \mu_k N$ so that

$f = \mu_k mg \cos\theta$.

Solving for a gives: $a = \frac{w_x + f}{m} = \frac{(mg\sin\theta + \mu_k mg\cos\theta)}{m} = \underline{g(\sin\theta + \mu_k\cos\theta)}$,

so that $a = (9.80 \text{ m/s}^2)(\sin 5° + (0.100)\cos 5°) = \underline{1.83 \text{ m/s}^2}$

17. *Consider the 52.0-kg mountain climber in Figure 5.20. (a) Find the tension ..*

Solution *(a)* $T\cos 31° + F_{\text{legs}} \sin 15° = mg$ *and* $T \sin 31° = F_{\text{legs}} \cos 15° \Rightarrow T = 1.88 F_{\text{legs}}$

$$F_{\text{legs}} = \frac{mg}{1.88\cos 31° + \sin 15°} = \frac{(52.0 \text{ kg})(9.80 \text{ m/s}^2)}{1.88\cos 31° + \sin 15°} = \underline{272 \text{ N}}$$

$$T = 1.88 F_{\text{legs}} = 1.88 \times 272 \text{ N} = \underline{512 \text{ N}}$$

(b) $\mu_s N \geq F_{\text{legs}} \sin 15° \Rightarrow \mu_s F_{\text{legs}} \cos 15° \geq F_{\text{legs}} \sin 15°$

Therefore $\mu_s \geq \tan 15° = \underline{0.268}$

Circular motion Newton's law of gravitation. Chapter 6

2 problems: 2, 5, 7, 10, 15, 19, 27 (starting on page 275 of text)

2. *Microwave ovens rotate at a rate of about 6 rev/min.*

Solution $\omega = 6 \text{ rpm} = \underline{0.1 \text{rps}} = \underline{0.63 \text{rad/s}}$

5. *A baseball pitcher brings his arm forward*

Solution $\omega = \frac{v}{r} = \frac{35.0 \text{ m/s}^2}{0.300 \text{ m}} = \underline{117 \text{ rad/s}}$

7. *A truck with 0.420 m radius tires travels at 32.0 m/s. What is the angular velocity of the rotating tires in radians per second? What is this in rev/min?*

Solution

$$\omega = \frac{v}{r} = \frac{32.0\ \text{m/s}}{0.420\ \text{m}} = \underline{76.2\ \text{rad/s}}$$

$$\omega = 76.2\ \text{rad/s} \times \frac{1\ \text{rev}}{2\,\pi\ \text{rad}} \times \frac{60\ \text{s}}{1\ \text{min}} = 728\ \text{rev/s} = \underline{728\ \ \text{rpm}}$$

10. A fairground ride spins its occupants inside a flying saucer-shaped container…

Solution

$$a_c = r\omega^2 \Rightarrow$$

$$\omega = \sqrt{\frac{a_c}{r}} = \sqrt{\frac{1.50\left(9.80\ \text{m/s}^2\right)}{8.00\ \text{m}}} = 1.36\ \text{rad/s} \times \frac{1\ \text{rev}}{2\pi\ \text{rad}} \times \frac{60\ \text{s}}{1\ \text{min}} = \underline{12.9\ \text{rev/min}}$$

15. *Helicopter blades withstand tremendous stresses.*

Solution

$$= \frac{300\ \text{rev}}{1\ \text{min}} \times \frac{2\quad \text{rad}}{1\ \text{rev}} \times \frac{1\ \text{min}}{60\ \text{s}} = 31.4\ \text{rad/s}$$

(a) $a_c = r\ \ ^2 = \left(4.00\ \text{m}\right)\left(31.4\ \text{rad/s}\right)^2 = \underline{3.95\times10^3\ \ \text{m/s}^2}$

(b) $v = r\omega = \left(4.00\,\text{m}\right)\left(31.4\ \ \text{rad/s}\right) = 125.7\ \text{m/s} = \underline{126\,\text{m/s}}$

$$\frac{125.7\ \text{m/s}}{340\,\text{m/s}} = 0.369 = \underline{36.9\,\%\ \ \text{the speed of sound}}$$

19. *A rotating space station is said to create "artificial gravity"—a loosely-defined*

Solution

$$a_c = r\omega^2 = g \Rightarrow \omega = \sqrt{\frac{g}{r}} = \left(\frac{9.80\ \text{m/s}^2}{100\ \text{m}}\right)^{1/2} = \underline{0.313\ \text{rad/s}}$$

27. *(a) What is the radius of a bobsled turn banked at 75.0° and taken at 30.0 m/s, assuming it is ideally banked? (b) Calculate the centripetal acceleration. (c) Does this acceleration seem large to you?*

Solution (a) For an ideally banked curve:

$$\theta = \tan^{-1}\frac{v^2}{rg},\ \text{so that}\ r = \frac{v^2}{g\tan\theta} = \frac{\left(30.0\ \text{m/s}^2\right)}{\left(9.80\ \text{m/s}^2\right)\tan 75.0^\circ} = \underline{24.6\ \text{m}}$$

(b) $a_c = \frac{v^2}{r} = \frac{(30.0\ \text{m/s})^2}{24.6\ \text{m}} = \underline{36.6\ \text{m/s}^2}$

(c) $\frac{a_c}{g} = \frac{36.6\ \text{m/s}^2}{9.80\ \text{m/s}^2} = 3.73 \Rightarrow \underline{a_c = 3.73\,g}$

This does not seem too large, but it is clear that bobsledders feel a lot of force on them going through sharply banked turns!

Work energy Chapter 7

3 problems. 6, 12, 15, 18, 24, 25, 34, 37, (starting on page 326)

6. *How much work is done by the boy pulling his sister 30.0 m in a wagon as shown in Figure 7.33? Assume no friction acts on the wagon.*

Solution

$W = Fd\cos\theta = 50.0\ \text{N} \times 30.0\ \text{m} \times \cos 30° = 1.299 \times 10^3\ \text{J} = \underline{1.30 \times 10^3\ \text{J}}$

12. *(a) Calculate the force needed to bring a 950-kg car to rest from..*

Solution

(a) $90.0\ \text{km/h} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{h}}{3600\ \text{s}} = 25.0\ \text{m/s}$

$W = Fd = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^{\ 2} \Rightarrow$

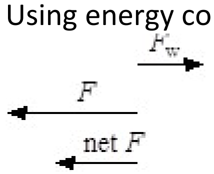
$F = \frac{-mv_0^{\ 2}}{2d} = \frac{-(950\ \text{kg})(25.0\ \text{m/s})^2}{2 \times 120\ \text{m}} = -2.474 \times 10^3\ \text{N} = \underline{-2470\ \text{N}}$

$F = \frac{-mv_0^{\ 2}}{2d} = \frac{-(950\ \text{kg})(25.0\ \text{m/s})^2}{2 \times 2.00\ \text{m}} = -1.484 \times 10^5\ \text{N} = \underline{-1.48 \times 10^5\ \text{N}}$

(b) $\frac{F_b}{F_a} = \underline{60.0}$

15. Using energy considerations, calculate the average force a 60.0-kg sprinter ..

Solution



$\text{net}\ F \times d = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^{\ 2} = \frac{1}{2}m(v^2 - v_0^{\ 2})$

$\text{net}\ F = \frac{m}{2d}(v^2 - v_0^{\ 2}) = \frac{60.0\ \text{kg}}{2 \times 25.0\ \text{m}}\left[(8.00\ \text{m/s})^2 - (2.00\ \text{m/s})^2\right] = 72.0\ \text{N}$

$\text{net}\ F = F - F_W \Rightarrow F = \text{net}\ F + F_W = 72.0\ \text{N} + 30.0\ \text{N} = \underline{102\ \text{N}}$

18. *Suppose a 350-g kookaburra (a large kingfisher bird) picks up a 75-g snake ..*

Solution

(a) $\text{PE} = mgh = (0.075\text{ kg})\,(9.80\text{ m/s}^2)\,(2.5\text{ m}) = 1.8375\text{ J} = \underline{1.8\text{ J}}$

(b) $\text{PE} = mgh = (0.350\text{ kg})\,(9.80\text{ m/s}^2)\,(2.5\text{ m}) = 8.575\text{ J} = \underline{8.6\text{ J}}$

24. *A 60.0-kg skier with an initial speed of 12.0 m/s coasts up a 2.50-m-high rise..*

Solution

$$\text{KE}_\text{i} + W_\text{nc} = \text{KE}_\text{f} + \text{PE}_\text{g}$$

$$\frac{1}{2}mv_0{}^2 - fd = \frac{1}{2}mv_\text{f}{}^2 + mgh$$

$$\frac{1}{2}mv_0{}^2 - \mu mg\cos\theta \times \frac{h}{\sin\theta} = \frac{1}{2}mv_\text{f}{}^2 + mgh$$

$$v_0^2 = v_f^2 + 2gh\,(1+\mu\cot\theta)$$

$$v_f = \left[v_0^2 - 2gh\,(1+\mu\cot\theta)\right]^{1/2} = \left[\begin{matrix}(12.0\text{ m/s})^2 - 2\,(9.80\text{ m/s}^2)\,(2.50\text{ m})\\ (1+0.0800\cot 35°)\end{matrix}\right]^{1/2} = \underline{9.46\text{ m/s}}$$

25.

Solution

(a) How high a hill can a car coast up (engine disengaged) if work done ..

(a) Initially the car's energy is all kinetic energy; finally it is all potential energy.

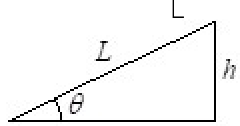
$$v_0 = 110\text{ km/h} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ h}}{3600s} = 30.56\text{ m/s}$$

$$\frac{1}{2}mv_0^2 = mgh \Rightarrow h = \frac{v_0^2}{2g} = \frac{(30.56\text{ m/s})^2}{2\,(9.80\text{ m/s}^2)} = 47.63\text{ m} = \underline{47.6\text{ m}}$$

(b) Since the car coasts only to 22.0 m, some of the energy E_f must be lost to thermal energy due to friction.

$$\frac{1}{2}mv_0^2 = mgh + E_\text{f} \Rightarrow E_\text{f} = m\left(\frac{v_0^2}{2} - gh\right)$$

$$= 750\text{ kg}\left[\frac{(30.56\text{ m/s})^2}{2} - (9.80\text{ m/s}^2)\,(22.0\text{ m})\right] = \underline{1.89\times10^5\text{ J}}$$

(c) 

$$h = L\sin\theta \Rightarrow L = \frac{h}{\sin\theta}, \text{ so that } W = FL = F\times\frac{h}{\sin\theta} \Rightarrow F = \frac{W\sin\theta}{h}$$

$$F = \frac{(1.89\times10^5\text{ J})\sin 2.5°}{22.0\text{ m}} = \underline{375\text{ N}}$$

34. *A large household air conditioner may consume 15.0 kW of power. What is the cost of operating this air conditioner 3.00 h per day for 30.0 d if the cost of electricity is $0.110 per* $\text{kW}\cdot\text{h}$ *?*

Solution

$$E = Pt = 15.0\ \text{kW} \times 30\ \text{d} \times \frac{3\ \text{h}}{1\ \text{d}} = 1.35\times10^{3}\ \text{kW}\cdot\text{h}$$

$$\text{cost} = \left(1.35\times10^{3}\ \text{kW}\cdot\text{h}\right)\times\frac{\$0.110}{\text{kW}\cdot\text{h}} = \$148.50 = \underline{\$149}$$

37. *A 500-kg dragster accelerates from rest to a final speed of 110 m/s in 400 m (about a quarter of a mile) and encounters an average frictional force of 1200 N. What is its average power output in watts and horsepower if this takes 7.30 s?*

Solution

Using the equation $KE_{\text{i}} + PE_{\text{i}} + W_{\text{nc}} + \text{OE}_{\text{i}} = \text{KE}_{\text{f}} + \text{PE}_{\text{f}} + \text{OE}_{\text{f}}$ to express conservation of energy and identifying that $\text{KE}_{\text{i}} = \text{PE}_{\text{i}} = \text{PE}_{\text{f}} = 0$ we see that

$$\Delta\text{OE} = \text{KE}_{\text{f}} - W_{\text{nc}}$$

Here $W_{\text{nc}} = fd$, and power $P = \dfrac{\Delta\text{OE}}{t}$, thus

$$P = \frac{(1/2)mv^{2} - fd}{t} = \frac{0.5\left(500\ \text{kg}\right)\left(110\ \text{m/s}\right)^{2} - \left(-1200\ \text{N}\right)\left(400\ \text{m}\right)}{7.30\ \text{s}}$$

$$= \frac{3.505\times10^{6}\ \text{J}}{7.30\ \text{s}} = \underline{4.80\times10^{5}\ \text{W}}$$

$$P = \left(4.801\times10^{5}\ \text{W}\right)\times\frac{1\ \text{hp}}{746\ \text{W}} = \underline{643\ \text{hp}}$$