Problem Workbook Solutions

Forces and the Laws of Motion 4

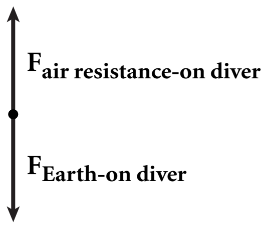
Additional Practice A

Givens | *Solutions*

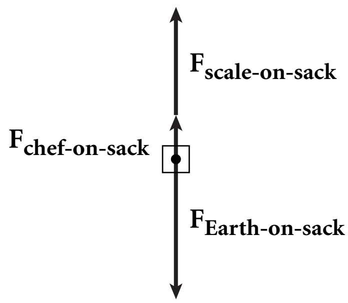
1.

a.

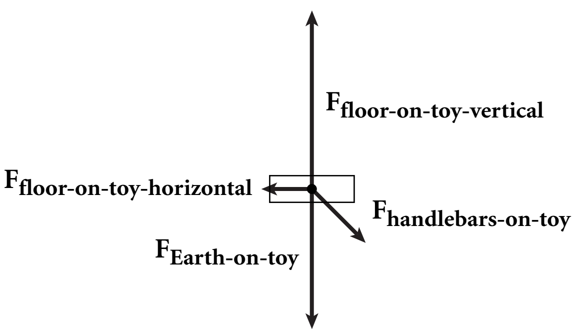
b.



2.



3.



Additional Practice B

1. $m_w = 75$ kg

$m_p = 275$ kg

$g = 9.81$ m/s^2

The normal force exerted by the platform on the weight lifter's feet is equal to and opposite of the combined weight of the weightlifter and the pumpkin.

$F_{net} = F_n - m_w g - m_p g = 0$

$F_n = (m_w + m_p)g = (75 \text{ kg} + 275 \text{ kg})\ (9.81 \text{ m/s}^2)$

$F_n = (3.50 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2) = 3.43 \times 10^3 \text{ N}$

$\mathbf{F_n}$ = $\boxed{3.43 \times 10^3 \text{ N upward against feet}}$

II

Givens | *Solutions*

2. $m_b = 253$ kg

$m_w = 133$ kg

$g = 9.81$ m/s^2

$F_{net} = F_{n,1} + F_{n,2} - m_b g - m_w g = 0$

The weight of the weightlifter and barbell is distributed equally on both feet, so the normal force on the first foot ($F_{n,1}$) equals the normal force on the second foot ($F_{n,2}$).

$$2F_{n,1} = (m_b + m_w)g = 2F_{n,2}$$

$$F_{n,1} = F_{n,2} = \frac{(m_b + m_b)g}{2} = \frac{(253 \text{ kg} + 33 \text{ kg})\left(9.81 \frac{\text{m}}{\text{s}^2}\right)}{2}$$

$$F_{n,1} = F_{n,2} = \frac{(386 \text{ kg})(9.81 \text{ m/s}^2)}{2} = 1.89 \times 10^3 \text{ N}$$

$$\mathbf{F_{n,1}} = \mathbf{F_{n,2}} = \boxed{1.89 \times 10^3 \text{ N upward on each foot}}$$

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3. $F_{down} = 1.70$ N

$F_{net} = 4.90$ N

$$F_{net}{}^2 = F_{forward}{}^2 + F_{down}{}^2$$

$$F_{forward} = \sqrt{F_{net}{}^2 - \text{F}_{\text{down}}{}^2} = \sqrt{(4.90 \text{ N})^2 - (1.70 \text{ N})^2}$$

$$F_{forward} = \sqrt{21.1 \text{ N}^2} = \boxed{4.59 \text{ N}}$$

II

4. $m = 3.10 \times 10^2$ kg

$g = 9.81$ m/s^2

$\theta_1 = 30.0°$

$\theta_2 = -30.0°$

$$F_{x,net} = \Sigma F_x = F_{T,1}(\sin \theta_1) + F_{T,2}(\sin \theta_2) = 0$$

$$F_{y,net} = \Sigma F_y = F_{T,1}(\cos \theta_1) + F_{T,2}(\cos \theta_2) + \text{Fg} = 0$$

$$F_{T,1}(\sin 30.0°) = -F_{T,2}[\sin(-30.0°)]$$

$$F_{T,1} = F_{T,2}$$

$$F_{T,1}(\cos \theta_1) + F_{T,1}(\cos \theta_2) = -F_g = mg$$

$$F_{T,1}(\cos 30.0°) + F_{T,1}[\cos(-30.0°)] = (3.10 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)$$

$$F_{T,1} = \frac{(3.10 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)}{(2)(\cos 30.0°)[\cos(-30.0°)]}$$

$$F_{T,1} = F_{T,2} = \boxed{1.76 \times 10^3 \text{ N}}$$

As the angles θ_1 and θ_2 become larger, cos θ_1 and cos θ_2 become smaller. Therefore, $F_{T,1}$ and $F_{T,2}$ must become larger in magnitude.

Givens | *Solutions*

5. $m = 155$ kg

$F_{T,1} = 2F_{T,2}$

$g = 9.81$ m/s^2

$\theta_1 = 90° - \theta_2$

$$F_{x,net} = F_{T,1}(\cos\theta_1) - F_{T,2}(\cos\theta_2) = 0$$

$$F_{y,net} = F_{T,1}(\sin\theta_1) + F_{T,2}(\sin\theta_2) - mg = 0$$

$$F_{T,1}[(\cos\theta_1) - \frac{1}{2}(\cos\theta_2)] = 0$$

$$2\,(\cos\theta_1) = \cos\theta_2 = \cos(90° - \theta_1) = \sin\theta_1$$

$$2 = \tan\theta_1$$

$$\theta_1 = \tan^{-1}(2) = 63°$$

$$\theta_2 = 90° - 63° = 27°$$

$$F_{T,1}(\sin\theta_1) + \frac{F_{T,1}}{2}(\sin\theta_2) = mg$$

$$F_{T,1} = \frac{mg}{(\sin\theta_1) + \frac{1}{2}(\sin\theta_2)}$$

$$F_{T,1} = \frac{(155\text{ kg})(9.81\text{ m/s}^2)}{(\sin 63°) + \frac{(\sin 27°)}{2}} = \frac{(155\text{ kg})(9.81\text{ m/s}^2)}{0.89 + 0.23} = \frac{(155\text{ kg})(9.81\text{ m})}{1.12}$$

$$F_{T,1} = \boxed{1.36 \times 1.36 \times 10^3\text{ N}}$$

$$F_{T,2} = \boxed{6.80 \times 10^2\text{ N}}$$

II

Additional Practice C

1. $v_i = 173$ km/h

$v_f = 0$ km/h

$\Delta x = 0.660$ m

$m = 70.0$ kg

$g = 9.81$ m/s^2

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(0\text{ km/h})^2 - (173\text{ km/h})^2](10^3\text{ m/km})^2(1\text{ h/3600 s})^2}{(2)(0.660\text{ m})}$$

$$a = -1.75 \times 10^3\text{ m/s}^2$$

$$F = ma = (70.0\text{ kg})(-1.75 \times 10^3\text{ m/s}^2) = \boxed{-1.22° \times 10^5\text{ N}}$$

$$F_g = mg = (70.0\text{ kg})(9.81\text{ m/s}^2) = \boxed{6.87 \times 10^2\text{ N}}$$

The force of deceleration is nearly 178 times as large as David Purley's weight.

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2. $m = 2.232 \times 10^6$ kg

$g = 9.81$ m/s^2

$a_{net} = 0$ m/s^2

a. $F_{net} = ma_{net} = F_{up} - mg$

$$F_{up} = ma_{net} + mg = m(a_{net} + g) = (2.232 \times 10^6\text{ kg})(0\text{ m/s}^2 + 9.81\text{ m/s}^2)$$

$$F_{up} = \boxed{2.19 \times 10^7\text{ N}} = mg$$

b. $F_{down} = mg(\sin\theta)$

$$a_{net} = \frac{F_{net}}{m} = \frac{F_{up} - F_{down}}{m} = \frac{mg - mg(\sin\theta)}{m}$$

$$a_{net} = g(1 - \sin\theta) = (9.81\text{ m/s}^2)[1.00 - (\sin 30.0°)] = \frac{9.81\text{ m/s}^2}{2} = 4.90\text{ m/s}^2$$

$$\mathbf{a_{net}} = \boxed{4.90\text{ m/s}^2\text{ up the incline}}$$

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3. $m = 40.00$ mg
$= 4.00 \times 10^{-5}$ kg

$g = 9.807$ m/s^2

$a_{net} = (400.0)g$

$$F_{net} = F_{beetle} - F_g = ma_{net} = m(400.0)\,g$$

$$F_{beetle} = F_{net} + F_g = m(400.0 + 1)g = m(401)g$$

$$F_{beetle} = (4.000 \times 10^{-5}\text{ kg})(9.807\text{ m/s}^2)(401) = \boxed{1.573 \times 10^{-1}\text{ N}}$$

$$F_{net} = F_{beetle} - F_g = m(400.0)\,g = (4.000 \times 10^{-5}\text{ kg})(9.807\text{ m/s}^2)(400.0)$$

$$F_{net} = \boxed{1.569 \times 10^{-1}\text{ N}}$$

The effect of gravity is negligible.

Givens	Solutions

4. $m_a = 54.0$ kg

$m_w = 157.5$ kg

$a_{net} = 1.00 \text{ m/s}^2$

$g = 9.81 \text{ m/s}^2$

The net forces on the lifted weight is

$$F_{w,net} = m_w a_{net} = F' - m_w g$$

where F' is the force exerted by the athlete on the weight.

The net force on the athlete is

$$F_{a,net} = F_{n,1} + F_{n,2} - F' - m_a g = 0$$

where $F_{n,1}$ and $F_{n,2}$ are the normal forces exerted by the ground on each of the athlete's feet, and $-F'$ is the force exerted by the lifted weight on the athlete.

The normal force on each foot is the same, so

$$F_{n,1} = F_{n,2} = F_n \quad \text{and}$$

$$F' = 2F_n - m_a g$$

Using the expression for F' in the equation for $F_{w,net}$ yields the following:

$$m_w a_{net} = (2F_n - m_a g) - m_a g$$

$$2F_n = m_w(a_{net} + g) + m_a g$$

$$F_n = \frac{m_w(a_{net} + g) + m_a g}{2} = \frac{(157.5 \text{ kg})(1.00 \text{ m/s}^2 + 9.81 \text{ m/s}^2) + (54.0 \text{ kg})}{2}$$

$$F_n = \frac{(157.5 \text{ kg})(10.81 \text{ m/s}^2) + (54.0 \text{ kg})(9.81 \text{ m/s}^2)}{2}$$

$$F_n = \frac{1702 \text{ N} + 5.30 \times 10^2 \text{ N}}{2} = \frac{2232 \text{ N}}{2} = 1116 \text{ N}$$

$$F_{n,1} - F_{n,2} = F_n = \boxed{1116 \text{ N upward}}$$

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5. $m = 2.20 \times 10^2$ kg

$a_{net} = 75.0 \text{ m/s}^2$

$g = 9.81 \text{ m/s}^2$

$$F_{net} = ma_{net} = F_{avg} - mg$$

$$F_{avg} = m(a_{net} + g) = (2.20 \times 10^2 \text{ kg})(75.0 \text{ m/s}^2 + 9.81 \text{ m/s}^2)$$

$$F_{avg} = (2.20 \times 10^2 \text{ kg})(84.8 \text{ m/s}^2) = 1.87 \times 10^4 \text{ N}$$

$$\mathbf{F_{avg}} = \boxed{1.87 \times 10^4 \text{ N upward}}$$

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6. $m = 2.00 \times 10^4$ kg

$\Delta t = 2.5$

$v_i = 0$ m/s

$v_f = 1.0$ m/s

$g = 9.81 \text{ m/s}^2$

$$a_{net} = \frac{v_f - v_i}{\Delta t} = \frac{(1.0 \text{ m/s} - 0.0 \text{ m/s})}{2.5 \text{ s}} = 0.40 \text{ m/s}^2$$

$$F_{net} = ma_{net} = F_T - mg$$

$$F_T = ma_{net} + mg = m(a_{net} + g)$$

$$F_T = (2.00 \times 10^4 \text{ kg})(0.40 \text{ m/s}^2 + 9.81 \text{ m/s}^2)$$

$$F_T = (2.00 \times 10^4 \text{ kg})(10.21 \text{ m/s}^2) = 2.04 \times 10^5 \text{ N}$$

$$F_T = \boxed{2.04 \times 10^5 \text{ N}}$$

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7. $m = 2.65$ kg

$\theta_1 = \theta_2 = 45.0°$

$a_{net} = 2.55 \text{ m/s}^2$

$g = 9.81 \text{ m/s}^2$

$$F_{x,net} = F_{T,1}(\cos \theta_1) - F_{T,2}(\cos \theta_2) = 0$$

$$F_{T,1}(\cos 45.0°) = F_{T,2}(\cos 45.0°)$$

$$F_{T,1} = F_{T,2}$$

$$F_{y,net} = ma_{net} = F_{T,1}(\sin \theta_1) + F_{T,2}(\sin \theta_2) - mg$$

$$F_T = F_{T,1} = F_{T,2}$$

$$\theta = \theta_1 = \theta_2$$

$$F_T(\sin \theta) + F_T(\sin \theta) = m(a_{net} + g)$$

$$2F_T(\sin \theta) = m(a_{net} + g)$$

Givens	*Solutions*
	$F_T = \frac{m(a_{net} + g)}{2\ (\sin\theta)} = \frac{(2.65\ kg)(2.55\ m/s^2 = 9.81\ m/s^2)}{(2)(\sin 45.0°)}$
	$F_T = \frac{(2.65\ kg)(12.36\ m/s^2)}{(2)(\sin 45.0°)} = 23.2\ N$
	$F_{T,1} = 23.2\ N$
	$F_{T,2} = 23.2\ N$
8. $m = 20.0\ kg$ $\Delta x = 1.55\ m$ $v_i = 0\ m/s$ $v_f = 0.550\ m/s$	$a_{net} = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{(0.550\ m/s)^2 - (0.00\ m/s)^2}{(2)(1.55\ m)} = 9.76 \times 10^{-2}\ m/s^2$ $F_{net} = ma_{net} = (20.0\ kg)(9.76 \times 10^{-2}\ m/s^2) = \boxed{1.95\ N}$
9. $m_{max} = 70.0\ kg$ $m = 45.0\ kg$ $g = 9.81\ m/s^2$	$F_{max} = m_{max}g = F_T$ $F_{max} = (70.0\ kg)(9.81\ m/s^2) = 687\ N$ $F_{net} = ma_{net} = F_T - mg = F_{max} - mg$ $a_{net} = \frac{F_{max}}{m} - g = \frac{687\ N}{45.0\ kg} - 9.81\ m/s^2 = 15.3\ m/s^2 - 9.81\ m/s^2 = 5.5\ m/s^2$ $\mathbf{a_{net}} = \boxed{5.5\ m/s^2\ \text{upward}}$
10. $m = 3.18 \times 10^5\ kg$ $F_{applied} = 81.0 \times 10^3\ N$ $F_{friction} = 62.0 \times 10^3\ N$	$F_{net} = F_{applied} - F_{friction} = (81.0 \times 10^3 - 62.0 \times 10^3\ N)$ $F_{net} = 19.0 \times 10^3\ N$ $a_{net} = \frac{F_{net}}{m} = \left(\frac{19.0 \times 10^3\ N}{3.18 \times 10^5\ kg}\right) = \boxed{5.97 \times 10^{-2}\ m/s^2}$
11. $m = 3.00 \times 10^3\ kg$ $F_{applied} = 4.00 \times 10^3\ N$ $\theta = 20.0°$ $F_{opposing} = (0.120)\ mg$ $g = 9.81\ m/s^2$	$F_{net} = ma_{net} = F_{applied}(\cos\theta) - F_{opposing}$ $a_{net} = \frac{F_{applied}(\cos\theta) - (0.120)\ mg}{m}$ $a_{net} = \frac{(4.00 \times 10^3\ N)(\cos 20.0°) - (0.120)(3.00 \times 10^3\ kg)(9.81\ m/s^2)}{3.00 \times 10^3\ kg}$ $a_{net} = \frac{3.76 \times 10^3\ N - 3.53 \times 10^3\ N}{3.00 \times 10^3\ kg} = \frac{2.3 \times 10^2\ N}{3.00 \times 10^3\ kg}$ $a_{net} = \boxed{7.7 \times 10^{-2}\ m/s^2}$
12. $m_c = 1.600 \times 10^3\ kg$ $m_w = 1.200 \times 10^3\ kg$ $v_i = 0\ m/s$ $g = 9.81\ m/s^2$ $\Delta y = 25.0\ m$	For the counterweight: The tension in the cable is F_T. $F_{net} = F_T - m_wg = m_wa_{net}$ For the car: $F_{net} = m_cg - F_T = m_ca_{net}$ Adding the two equations yields the following: $m_cg - m_wg = (m_w + m_c)a_{net}$ $a_{net} = \frac{(m_c - m_w)g}{m_c + m_w} = \frac{(1.600 \times 10^3\ kg - 1.200 \times 10^3\ kg)(9.81\ m/s^2)}{1.600 \times 10^3\ kg + 1.200 \times 10^3\ kg}$ $a_{net} = \frac{(4.00 \times 10^2\ kg)(9.81\ m/s^2)}{2.800 \times 10^3\ kg} = \boxed{1.40\ m/s^2}$

Givens	*Solutions*
	$v_f = \sqrt{2a_{net}\Delta y + v_i^2} = \sqrt{(2)(1.40\text{ m/s}^2)(25.0\text{ m}) + (0\text{ m/s})^2}$
	$v_f = \boxed{8.37\text{ m/s}}$

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13. $m = 409$ kg
$d = 6.00$ m
$\theta = 30.0°$
$g = 9.81\text{ m/s}^2$
$F_{applied} = 2080$ N
$v_i = 0$ m/s

a. $F_{net} = F_{applied} - mg(\sin\theta) = 2080\text{ N} - (409\text{ kg})(9.81\text{ m/s}^2)(\sin 30.0°)$

$F_{net} = 2080\text{ N} - 2010\text{ N} = 70\text{ N}$

$\mathbf{F_{net}} = \boxed{70\text{ N at }30.0°\text{ above the horizontal}}$

b. $a_{net} = \dfrac{F_{net}}{m} = \dfrac{70\text{ N}}{409\text{ kg}} = 0.2\text{ m/s}^2$

$\mathbf{a_{net}} = \boxed{0.2\text{ m/s}^2\text{ at }30.0°\text{ above the horizontal}}$

c. $d = v_i\Delta t + \dfrac{1}{2}a_{net}\Delta t^2 = (0\text{ m/s})\Delta t + \dfrac{1}{2}(0.2\text{ m/s}^2)\Delta t^2$

$\Delta t = \sqrt{\dfrac{(2)(6.00\text{ m})}{(0.2\text{ m/s}^2)}} = \boxed{8\text{ s}}$

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14. $a_{max} = 0.25\text{ m/s}^2$
$F_{max} = 57$ N
$F_{app} = 24$ N

a. $m = \dfrac{F_{max}}{a_{max}} = \dfrac{57\text{ N}}{0.25\text{ m/s}^2} = \boxed{2.3 \times 10^2\text{ kg}}$

b. $F_{net} = F_{max} - F_{app} = 57\text{ N} - 24\text{ N} = 33\text{ N}$

$a_{net} = \dfrac{F_{net}}{m} = \dfrac{33\text{ N}}{2.3 \times 10^2\text{ kg}} = \boxed{0.14\text{ m/s}^2}$

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15. $m = 2.55 \times 10^3$ kg
$F_T = 7.56 \times 10^3$ N
$\theta_T = -72.3°$
$F_{buoyant} = 3.10 \times 10^4$ N
$F_{wind} = -920$ N
$g = 9.81\text{ m/s}^2$

a. $F_{x,net} = \Sigma F_x = ma_{x,net} = F_T(\cos\theta_T) + F_{wind}$

$F_{x,net} = (7.56 \times 10^3\text{ N})[\cos(-72.3°)] - 920\text{ N} = 2.30 \times 10^3\text{ N} - 920\text{ N} = 1.38 \times 10^3\text{ N}$

$F_{y,net} = \Sigma F_y = ma_{y,net} = F_T(\sin\theta_T) + F_{buoyant} + F_g = F_T(\sin\theta_T) + F_{buoyant} - mg$

$F_{y,net} = (7.56 \times 10^3\text{ N})[\sin(-72.3°)] = 3.10 \times 10^4\text{ N} - (2.55 \times 10^3\text{ kg})(9.81\text{ m/s}^2)$

$F_{y,net} = -7.20 \times 10^3\text{ N} + 3.10 \times 10^4\text{ N} - 2.50 \times 10^4 = -1.2 \times 10^3\text{ N}$

$F_{net} = \sqrt{(F_{x,net})^2 + (F_{y,net})^2} = \sqrt{(1.38 \times 10^3\text{ N})^2 + (-1.2 \times 10^3\text{ N})^2}$

$F_{net} = \sqrt{1.90 \times 10^6\text{ N}^2 + 1.4 \times 10^6\text{ N}^2}$

$F_{net} = \sqrt{3.3 \times 10^6\text{ N}^2} = 1.8 \times 10^3\text{ N}$

$\theta = \tan^{-1}\left(\dfrac{F_{y,\,net}}{F_{x,\,net}}\right) = \tan^{-1}\left(\dfrac{-1.2 \times 10^3\text{ N}}{1.38 \times 10^3\text{ N}}\right)$

$\theta = -41°$

$\mathbf{F_{net}} = \boxed{1.8 \times 10^3\text{ N at }41°\text{ below the horizontal}}$

b. $a_{net} = \dfrac{F_{net}}{m} = \dfrac{1.8 \times 10^3\text{ N}}{2.55 \times 10^3\text{ kg}}$

$a_{net} = \boxed{0.71\text{ m/s}^2}$

$\Delta y = -45.0$ m
$v_i = 0$ m/s

c. Because $v_i = 0$

$\Delta y = \dfrac{1}{2}a_{y,net}\Delta t^2$

$\Delta x = \dfrac{1}{2}a_{x,net}\Delta t^2$

$\Delta x = \dfrac{a_{x,net}}{a_{y,net}}$ $\Delta y = \dfrac{a_{net}(\cos\theta)}{a_{net}(\sin\theta)}$ $\Delta y = \dfrac{\Delta y}{\tan\theta}$

$\Delta x = \dfrac{-45.0\text{ m}}{\tan(-41°)} = \boxed{52\text{ m}}$

Additional Practice D

Givens	*Solutions*
1. $m = 11.0$ kg $\mu_k = 0.39$ $g = 9.81$ m/s^2	$F_k = \mu_k F_n = \mu_k mg$ $F_k = (0.39)\ (11.0 \text{ kg})(9.81 \text{ m/s}^2) = \boxed{42.1 \text{ N}}$
2. $m = 2.20 \times 10^5$ kg $\mu_s = 0.220$ $g = 9.81$ m/s^2	$F_{s,max} = \mu_s F_n = \mu_s mg$ $F_{s,max} = (0.220)(2.20 \times 10^5 \text{ kg})(9.91 \text{ m/s}^2) = \boxed{4.75 \times 10^5 \text{ N}}$
3. $m = 25.0$ kg $F_{applied} = 59.0$ N $\theta = 38.0°$ $\mu_s = 0.599$ $g = 9.81$ m/s^2	$F_{s,max} = \mu_s F_m$ $F_n = mg(\cos\theta) + F_{applied}$ $F_{s,max} = \mu_s[mg(\cos\theta) = F_{applied}] = (0.599)[(25.0 \text{ kg})(9.81 \text{ m/s}^2)(\cos 38.0° + 59.0 \text{ N}]$ $F_{s,max} = (0.599)(193 \text{ N} + 59 \text{ N}) = (0.599)(252 \text{ N}) = \boxed{151 \text{ N}}$ Alternatively, $F_{net} = mg(\sin\theta) - F_{s,max} = 0$ $F_{s,max} = mg(\sin\theta) = (25.0 \text{ kg})(9.81 \text{ m/s}^2)(\sin 38.0°) = \boxed{151 \text{ N}}$
4. $\theta = 38.0°$ $g = 9.81$ m/s^2	$F_{net} = mg(\sin\theta) - F_k = 0$ $F_k = \mu_k F_n = \mu_k mg(\cos\theta)$ $\mu_k mg(\cos\theta) = mg(\sin\theta)$ $\mu_k = \frac{\sin\theta}{\cos\theta} = \tan\theta = \tan 38.0°$ $\mu_k = \boxed{0.781}$
5. $\theta = 5.2°$ $g = 9.81$ m/s^2	$F_{net} = mg(\sin\theta) - F_k = 0$ $F_k = \mu_k F_n = \mu_k mg(\cos\theta)$ $\mu_k mg(\cos\theta) = mg(\sin\theta)$ $\mu_k = \frac{\sin\theta}{\cos\theta} = \tan\theta = \tan 5.2°$ $\mu_k = \boxed{0.091}$

II

Givens	Solutions
6. $m = 281.5$ kg $\theta = 30.0°$	$F_{net} = 3mg(\sin\theta) - \mu_s(3mg)(\cos\theta) - F_{applied} = 0$ $F_{applied} = mg$ $\mu_s = \dfrac{3mg(\sin\theta) - mg}{3mg(\cos\theta)} = \dfrac{3(\sin\theta) - 1.00}{3(\cos\theta)} = \dfrac{(3)(\sin 30.0°) - 1.00}{(3)(\cos 30.0°)}$ $\mu_s = \dfrac{1.50 - 1.00}{(3)(\cos 30.0°)} = \dfrac{0.50}{(3)(\cos 30.0°)}$ $\mu_s = \boxed{0.19}$
7. $m = 1.90 \times 10^5$ kg $\mu_s = 0.460$ $g = 9.81$ m/s^2	$F_{net} = F_{applied} - F_k = 0$ $F_k = \mu_k F_n = \mu_k mg$ $F_{applied} = \mu_k mg = (0.460)(1.90 \times 10^5 \text{ kg})(9.81 \text{ m/s}^2)$ $F_{applied} = \boxed{8.57 \times 10^5 \text{ N}}$
8. $F_{applied} = 6.0 \times 10^3$ N $\mu_k = 0.77$ $g = 9.81$ m/s^2	$F_{net} = F_{applied} - F_k = 0$ $F_k = \mu_k F_n$ $F_n = \dfrac{F_{applied}}{\mu_k} = \dfrac{6.0 \times 10^3 \text{ N}}{0.77} = \boxed{7.8 \times 10^3 \text{ N}}$ $F_n = mg$ $m = \dfrac{F_n}{g} = \dfrac{7.8 \times 10^3 \text{ N}}{9.81 \text{ m/s}^2} = \boxed{8.0 \times 10^2 \text{ kg}}$
9. $F_{applied} = 1.13 \times 10^8$ N $\mu_s = 0.741$	$F_{net} = F_{applied} - F_{s,max} = 0$ $F_{s,max} = \mu_s F_n = \mu_s mg$ $m = \dfrac{F_{applied}}{\mu_s g} = \dfrac{1.13 \times 10^8 \text{ N}}{(0.741)(9.81 \text{ m/s}^2} = \boxed{1.55 \times 10^2 \text{ kg}}$
10. $m = 3.00 \times 10^3$ kg $\theta = 31.0°$ $g = 9.81$ m/s^2	$F_{net} = mg(\sin\theta) - F_k = 0$ $F_k = \mu_k F_n = \mu_k mg(\cos\theta)$ $\mu_k mg(\cos\theta) = mg(\sin\theta)$ $\mu_k = \dfrac{\sin\theta}{\cos\theta} = \tan\theta = \tan 31.0°$ $\mu_k = \boxed{0.601}$ $F_k = \mu_k mg(\cos\theta) = (0.601)(3.00 \times 10^3 \text{ kg})(9.81 \text{ m/s}^2)(\cos 31.0°)$ $F_k = \boxed{1.52 \times 10^4 \text{ N}}$ Alternatively, $F_k = mg(\sin\theta) = (3.00 \times 10^3 \text{ kg})(9.81 \text{ m/s}^2)(\sin 31.0°) = \boxed{1.52 \times 10^4 \text{ N}}$

II

Additional Practice E

Givens	Solutions
1. $F_{applied} = 130$ N	$F_{net} = ma_{net} = F_{applied} - F_k$
$a_{net} = 1.00$ m/s^2	$F_k = \mu_k F_n = \mu_k mg$
$\mu_k = 0.158$	$ma_{net} + \mu_k mg = F_{applied}$
$g = 9.81$ m/s^2	$m(a_{net} + \mu_k g) = F_{applied}$

$$m = \frac{F_{applied}}{a_{net} + \mu_k g} = \frac{130 \text{ N}}{1.00 \text{ m/s}^2 + (0.158)(9.81 \text{ m/s}^2)}$$

$$m = \frac{130 \text{ N}}{1.00 \text{ m/s}^2 + 1.55 \text{ m/s}^2} = \frac{130 \text{ N}}{2.55 \text{ m/s}^2} = \boxed{51 \text{ kg}}$$

Givens	Solutions
2. $F_{net} = -2.00 \times 10^4$ N	$F_{net} = ma_{net} = mg(\sin\theta) - F_k$
$\theta = 10.0°$	$F_k = \mu_k F_n = \mu_k m_g(\cos\theta)$
$\mu_k = 0.797$	$m[g(\sin\theta) - \mu_k g(\cos\theta)] = F_{net}$
$g = 9.81$ m/s^2	

$$m = \frac{F_{net}}{g[\sin\theta - \mu_k(\cos\theta)]} = \frac{-2.00 \times 10^4 \text{ N}}{(9.81 \text{ m/s}^2)[(\sin 10.0°) - (0.797)(\cos 10.0°)]}$$

$$m = \frac{-2.00 \times 10^4 \text{ N}}{(9.81 \text{ m/s}^2)(0.174 - 0.785)} = \frac{-2.00 \times 10^4 \text{ N}}{(9.81 \text{ m/s}^2)(-0.611)}$$

$$m = \boxed{3.34 \times 10^3 \text{ kg}}$$

$$F_n = mg(\cos\theta) = (3.34 \times 10^3 \text{ kg})(9.81 \text{ m/s}^2)(\cos 10.0°) = \boxed{3.23 \times 10^4 \text{ N}}$$

Givens	Solutions
3. $F_{net} = 6.99 \times 10^3$ N	$F_{net} = ma_{net} = mg(\sin\theta) - F_k$
$\theta = 45.0°$	$F_k = \mu_k F_n = \mu_k mg(\cos\theta)$
$\mu_k = 0.597$	$m[g(\sin\theta) - \mu_k g(\cos\theta)] = F_{net}$

$$m = \frac{F_{net}}{g[\sin\theta - \mu_k(\cos\theta)]} = \frac{6.99 \times 10^3 \text{ N}}{(9.81 \text{ m/s}^2)[(\sin 45.0°) - (0.597)(\cos 45.0°)]}$$

$$m = \frac{6.99 \times 10^3 \text{ N}}{(9.81 \text{ m/s}^2)(0.707 - 0.422)} = \frac{6.99 \times 10^3 \text{ N}}{(9.81 \text{ m/s}^2)(0.285)}$$

$$m = \boxed{2.50 \times 10^3 \text{ kg}}$$

$$F_n = mg(\cos\theta) = (2.50 \times 10^3 \text{ kg})(9.81 \text{ m/s}^2)(\cos 45.0°) = \boxed{1.73 \times 10^4 \text{ N}}$$

Givens	Solutions
4. $m = 9.50$ kg	$F_{net} = ma_{net} = F_{applied} - F_k - mg(\sin\theta)$
$\theta = 30.0°$	$F_k = \mu_k F_n = \mu_k mg(\cos\theta)$
$F_{applied} = 80.0$ N	$\mu_k mg(\cos\theta) = F_{applied} - ma_{net} - mg(\sin\theta)$
$a_{net} = 1.64$ m/s^2	
g = 9.81 m/s^2	

$$\mu_k = \frac{F_{applied} - m[a_{net} + g(\sin\theta)]}{mg(\cos\theta)}$$

$$\mu_k = \frac{80.0 \text{ N} - (9.50 \text{ kg})[1.64 \text{ m/s}^2 + (9.81 \text{ m/s}^2)(\sin 30.0°)]}{(9.50 \text{ kg})(9.81 \text{ m/s}^2)(\cos 30.0°)}$$

II

Givens	*Solutions*
	$\mu_k = \frac{80.0 \text{ N} - (9.50 \text{ kg})[1.64 \text{ m/s}^2 + 4.90 \text{ m/s}^2)}{(9.50 \text{ kg})(9.81 \text{ m/s}^2)(\cos 30.0°)} = \frac{80.0 \text{ N} - (9.50 \text{ kg})(6.54 \text{ m/s}^2)}{(9.50 \text{ kg})(9.81 \text{ m/s}^2)(\cos 30.0°)}$ $\mu_k = \frac{80.0 \text{ N} - 62.1 \text{ N}}{(9.50 \text{ kg})(9.81 \text{ m/s}^2)(\cos 30.0°)} = \frac{17.9 \text{ N}}{(9.50 \text{ kg})(9.81 \text{ m/s}^2)(\cos 30.0°)}$ $\mu_k = \boxed{0.222}$
5. $m = 1.89 \times 10^5$ kg $F_{applied} = 7.6 \times 10^5$ N $a_{net} = 0.11 \text{ m/s}^2$	$F_{net} = ma_{net} = F_{applied} - F_k$ $F_k = F_{applied} - ma_{net} = 7.6 \times 10^5 \text{ N} - (1.89 \times 10^5)(0.11 \text{ m/s}^2) = 7.6 \times 10^5 \text{ N} - 2.1 \times 10^4 \text{ N}$ $F_k = \boxed{7.4 \times 10^5 \text{ N}}$
6. $\theta = 38.0°$ $\mu_k = 0.100$ $g = 9.81 \text{ m/s}^2$	$F_{net} = ma_{net} = mg(\sin \theta) - F_k$ $F_k = \mu_k F_n = \mu_k mg(\cos \theta)$ $ma_{net} = mg[\sin \theta - \mu_k(\cos \theta)]$ $a_{net} = g[\sin \theta - \mu_k(\cos \theta)] = (9.81 \text{ m/s}^2)[(\sin 38.0°) - (0.100)(\cos 38.0°)]$ $a_{net} = (9.81 \text{ m/s}^2)(0.616 - 7.88 \times 10^{-2}) = (9.81 \text{ m/s}^2)(0.537)$ $a_{net} = \boxed{5.27 \text{ m/s}^2}$ Acceleration is independent of the rider's and sled's masses. (Masses cancel.)
7. $\Delta t = 6.60$ s $\theta = 34.0°$ $\mu_k = 0.198$ $g = 9.81 \text{ m/s}^2$ $v_i = 0$ m/s	$F_{net} = ma_{net} = mg(\sin \theta) - F_k$ $F_k = \mu_k F_n = \mu_k mg(\cos \theta)$ $ma_{net} = mg[\sin \theta - \mu_k(\cos \theta)]$ $a_{net} = g[\sin \theta - \mu_k(\cos \theta)] = (9.81 \text{ m/s}^2)[(\sin 34.0°) - (0.198)(\cos 34.0°)]$ $a_{net} = (9.81 \text{ m/s}^2)(0.559 - 0.164) = (9.81 \text{ m/s}^2)(0.395)$ $a_{net} = \boxed{3.87 \text{ m/s}^2}$ $v_f = v_i + a_{net}\Delta t = 0 \text{ m/s} + (3.87 \text{ m/s}^2)(6.60 \text{ s})$ $v_f = \boxed{25.5 \text{ m/s}^2 = 92.0 \text{ km/h}}$

II