E3-1 The Earth orbits the sun with a speed of 29.8 km/s. The distance to Pluto is 5900×10^6 km. The time it would take the Earth to reach the orbit of Pluto is

$$t = (5900\times10^6 \text{ km})/(29.8 \text{ km/s}) = 2.0\times10^8 \text{ s},$$

or 6.3 years!

E3-2 (a) $a = F/m = (3.8\,\text{N})/(5.5\,\text{kg}) = 0.69\,\text{m/s}^2$.
(b) $t = v_\text{f}/a = (5.2\,\text{m/s})/(0.69\,\text{m/s}^2) = 7.5\,\text{s}$.
(c) $x = at^2/2 = (0.69\,\text{m/s}^2)(7.5\,\text{s})^2/2 = 20\,\text{m}$.

$\boxed{\textbf{E3-3}}$ Assuming constant acceleration we can find the average speed during the interval from Eq. 2-27

$$v_{\text{av},x} = \frac{1}{2}(v_x + v_{0x}) = \frac{1}{2}\big((5.8\times10^6 \text{ m/s}) + (0)\big) = 2.9\times10^6 \text{ m/s}.$$

From this we can find the time spent accelerating from Eq. 2-22, since $\Delta x = v_{\text{av},x}\Delta t$. Putting in the numbers $\Delta t = 5.17\times10^{-9}$s. The acceleration is then

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{(5.8\times10^6 \text{ m/s}) - (0)}{(5.17\times10^{-9}\text{s})} = 1.1\times10^{15}\text{m/s}^2.$$

The net force on the electron is from Eq. 3-5,

$$\sum F_x = ma_x = (9.11\times10^{-31}\text{kg})(1.1\times10^{15}\text{m/s}^2) = 1.0\times10^{-15}\,\text{N}.$$

E3-4 The average speed while decelerating is $v_\text{av} = 0.7\times10^7\text{m/s}$. The time of deceleration is $t = x/v_\text{av} = (1.0\times10^{-14}\text{m})/(0.7\times10^7\text{m/s}) = 1.4\times10^{-21}\,\text{s}$. The deceleration is $a = \Delta v/t = (-1.4\times10^7\text{m/s})/(1.4\times10^{-21}\,\text{s}) = -1.0\times10^{28}\text{m/s}^2$. The force is $F = ma = (1.67\times10^{-27}\text{kg})(1.0\times10^{28}\text{m/s}^2) = 17\,\text{N}$.

$\boxed{\textbf{E3-5}}$ The *net* force on the sled is 92 N−90 N= 2 N; subtract because the forces are in opposite directions. Then

$$a_x = \frac{\sum F_x}{m} = \frac{(2\,\text{N})}{(25\,\text{kg})} = 8.0\times10^{-2}\text{m/s}^2.$$

E3-6 53 km/hr is 14.7 m/s. The average speed while decelerating is $v_\text{av} = 7.4\,\text{m/s}$. The time of deceleration is $t = x/v_\text{av} = (0.65\,\text{m})/(7.4\,\text{m/s}) = 8.8\times10^{-2}\,\text{s}$. The deceleration is $a = \Delta v/t = (-14.7\,\text{m/s})/(8.8\times10^{-2}\,\text{s}) = -17\times10^2\text{m/s}^2$. The force is $F = ma = (39\text{kg})(1.7\times10^2\text{m/s}^2) = 6600\,\text{N}$.

E3-7 Vertical acceleration is $a = F/m = (4.5\times10^{-15}\text{N})/(9.11\times10^{-31}\text{kg}) = 4.9\times10^{15}\text{m/s}^2$. The electron moves horizontally 33 mm in a time $t = x/v_x = (0.033\,\text{m})/(1.2\times10^7\text{m/s}) = 2.8\times10^{-9}\,\text{s}$. The vertical distance deflected is $y = at^2/2 = (4.9\times10^{15}\text{m/s}^2)(2.8\times10^{-9}\,\text{s})^2/2 = 1.9\times10^{-2}\text{m}$.

E3-8 (a) $a = F/m = (29\,\text{N})/(930\,\text{kg}) = 3.1\times10^{-2}\,\text{m/s}^2$.
(b) $x = at^2/2 = (3.1\times10^{-2}\,\text{m/s}^2)(86400\,\text{s})^2/2 = 1.2\times10^8\,\text{m}$.
(c) $v = at = (3.1\times10^{-2}\,\text{m/s}^2)(86400\,\text{s}) = 2700\,\text{m/s}$.

$\boxed{\textbf{E3-9}}$ Write the expression for the motion of the first object as $\sum F_x = m_1 a_{1x}$ and that of the second object as $\sum F_x = m_2 a_{2x}$. In both cases there is only one force, F, on the object, so $\sum F_x = F$. We will solve these for the mass as $m_1 = F/a_1$ and $m_2 = F/a_2$. Since $a_1 > a_2$ we can conclude that $m_2 > m_1$

(a) The acceleration of and object with mass $m_2 - m_1$ under the influence of a single force of magnitude F would be

$$a = \frac{F}{m_2 - m_1} = \frac{F}{F/a_2 - F/a_1} = \frac{1}{1/(3.30\,\mathrm{m/s^2}) - 1/(12.0\,\mathrm{m/s^2})},$$

which has a numerical value of $a = 4.55$ m/s^2.

(b) Similarly, the acceleration of an object of mass $m_2 + m_1$ under the influence of a force of magnitude F would be

$$a = \frac{1}{1/a_2 + 1/a_1} = \frac{1}{1/(3.30\,\mathrm{m/s^2}) + 1/(12.0\,\mathrm{m/s^2})},$$

which is the same as part (a) except for the sign change. Then $a = 2.59$ m/s^2.

E3-10 (a) The required acceleration is $a = v/t = 0.1c/t$. The required force is $F = ma = 0.1mc/t$. Then

$$F = 0.1(1200\times 10^3\,\mathrm{kg})(3.00\times 10^8\mathrm{m/s})/(2.59\times 10^5\mathrm{s}) = 1.4\times 10^8\mathrm{N},$$

and

$$F = 0.1(1200\times 10^3\,\mathrm{kg})(3.00\times 10^8\mathrm{m/s})/(5.18\times 10^6\mathrm{s}) = 6.9\times 10^6\mathrm{N},$$

(b) The distance traveled during the acceleration phase is $x_1 = at_1^2/2$, the time required to travel the remaining distance is $t_2 = x_2/v$ where $x_2 = d - x_1$. d is 5 light-months, or $d = (3.00\times 10^8\mathrm{m/s})(1.30\times 10^7\mathrm{s}) = 3.90\times 10^{15}\mathrm{m}$. Then

$$t = t_1 + t_2 = t_1 + \frac{d - x_1}{v} = t_1 + \frac{2d - at_1^2}{2v} = t_1 + \frac{2d - vt_1}{2v}.$$

If t_1 is 3 days, then

$$t = (2.59\times 10^5\mathrm{s}) + \frac{2(3.90\times 10^{15}\mathrm{m}) - (3.00\times 10^7\mathrm{m/s})(2.59\times 10^5\mathrm{s})}{2(3.00\times 10^7\mathrm{m/s})} = 1.30\times 10^8\mathrm{s} = 4.12\ \mathrm{yr},$$

if t_1 is 2 months, then

$$t = (5.18\times 10^6\mathrm{s}) + \frac{2(3.90\times 10^{15}\mathrm{m}) - (3.00\times 10^7\mathrm{m/s})(5.18\times 10^6\mathrm{s})}{2(3.00\times 10^7\mathrm{m/s})} = 1.33\times 10^8\mathrm{s} = 4.20\ \mathrm{yr},$$

$\boxed{\textbf{E3-11}}$ (a) The net force on the second block is given by

$$\sum F_x = m_2 a_{2x} = (3.8\,\mathrm{kg})(2.6\,\mathrm{m/s^2}) = 9.9\,\mathrm{N}.$$

There is only one (relevant) force on the block, the force of block 1 on block 2.

(b) There is only one (relevant) force on block 1, the force of block 2 on block 1. By Newton's third law this force has a magnitude of 9.9 N. Then Newton's second law gives $\sum F_x = -9.9$ N$= m_1 a_{1x} =$ (4.6 kg)a_{1x}. So $a_{1x} = -2.2$ m/s^2 at the instant that $a_{2x} = 2.6$ m/s^2.

E3-12 (a) $W = (5.00\ \mathrm{lb})(4.448\,\mathrm{N/lb}) = 22.2\,\mathrm{N}$; $m = W/g = (22.2\,\mathrm{N})/(9.81\,\mathrm{m/s^2}) = 2.26\,\mathrm{kg}$.

(b) $W = (240\ \mathrm{lb})(4.448\,\mathrm{N/lb}) = 1070\,\mathrm{N}$; $m = W/g = (1070\,\mathrm{N})/(9.81\,\mathrm{m/s^2}) = 109\,\mathrm{kg}$.

(c) $W = (3600\ \mathrm{lb})(4.448\,\mathrm{N/lb}) = 16000\,\mathrm{N}$; $m = W/g = (16000\,\mathrm{N})/(9.81\,\mathrm{m/s^2}) = 1630\,\mathrm{kg}$.

E3-13 (a) $W = (1420.00\text{ lb})(4.448\,\text{N/lb}) = 6320\,\text{N}$; $m = W/g = (6320\,\text{N})/(9.81\,\text{m/s}^2) = 644\,\text{kg}$.
(b) $m = 412\,\text{kg}$; $W = mg = (412\,\text{kg})(9.81\,\text{m/s}^2) = 4040\,\text{N}$.

E3-14 (a) $W = mg = (75.0\,\text{kg})(9.81\,\text{m/s}^2) = 736\,\text{N}$.
(b) $W = mg = (75.0\,\text{kg})(3.72\,\text{m/s}^2) = 279\,\text{N}$.
(c) $W = mg = (75.0\,\text{kg})(0\,\text{m/s}^2) = 0\,\text{N}$.
(d) The mass is 75.0 kg at all locations.

$\boxed{\textbf{E3-15}}$ If $g = 9.81$ m/s^2, then $m = W/g = (26.0\text{ N})/(9.81\text{ m/s}^2) = 2.65$ kg.
(a) Apply $W = mg$ again, but now $g = 4.60$ m/s^2, so at this point $W = (2.65\text{ kg})(4.60\text{ m/s}^2) =$ 12.2 N.
(b) If there is no gravitational force, there is no weight, because $g = 0$. There is still mass, however, and that mass is still 2.65 kg.

E3-16 Upward force balances weight, so $F = W = mg = (12000\,\text{kg})(9.81\,\text{m/s}^2) = 1.2\times10^5\text{N}$.

E3-17 Mass is $m = W/g$; net force is $F = ma$, or $F = Wa/g$. Then

$$F = (3900\text{ lb})(13\text{ ft/s}^2)/(32\text{ ft/s}^2) = 1600\text{ lb}.$$

E3-18 $a = \Delta v/\Delta t = (450\,\text{m/s})/(1.82\,\text{s}) = 247\,\text{m/s}^2$. Net force is $F = ma = (523\,\text{kg})(247\,\text{m/s}^2) = 1.29\times10^5\text{N}$.

$\boxed{\textbf{E3-19}}$ $\sum F_x = 2(1.4\times10^5\text{ N}) = ma_x$. Then $m = 1.22\times10^5$ kg and

$$W = mg = (1.22\times10^5\text{kg})(9.81\,\text{m/s}^2) = 1.20\times10^6\text{ N}.$$

E3-20 Do part (b) first; there must be a 10 lb force to support the mass. Now do part (a), but cover up the left hand side of both pictures. If you can't tell which picture is which, then they must both be 10 lb!

E3-21 (b) Average speed during deceleration is 40 km/h, or 11 m/s. The time taken to stop the car is then $t = x/v_{\text{av}} = (61\,\text{m})/(11\,\text{m/s}) = 5.6\,\text{s}$.
(a) The deceleration is $a = \Delta v/\Delta t = (22\,\text{m/s})/(5.6\,\text{s}) = 3.9\,\text{m/s}^2$. The braking force is $F = ma = Wa/g = (13,000\,\text{N})(3.9\,\text{m/s}^2)/(9.81\,\text{m/s}^2) = 5200\,\text{N}$.
(d) The deceleration is same; the time to stop the car is then $\Delta t = \Delta v/a = (11\,\text{m/s})/(3.9\,\text{m/s}^2) = 2.8\,s$.
(c) The distance traveled during stopping is $x = v_{\text{av}}t = (5.6\,\text{m/s})(2.8\,\text{s}) = 16\,\text{m}$.

E3-22 Assume acceleration of free fall is $9.81\,\text{m/s}^2$ at the altitude of the meteor. The net force is $F_{\text{net}} = ma = (0.25\,\text{kg})(9.2\,m/\text{s}^2) = 2.30\,\text{N}$. The weight is $W = mg = (0.25\,kg)(9.81\,\text{m/s}^2) = 2.45\,\text{N}$. The retarding force is $F_{\text{net}} - W = (2.3\,\text{N}) - (2.45\,\text{N}) = -0.15\,\text{N}$.

$\boxed{\textbf{E3-23}}$ (a) Find the time during the "jump down" phase from Eq. 2-30.

$$(0\text{ m}) = (0.48\text{ m}) + (0)t - \frac{1}{2}(9.8\text{ m/s}^2)t^2,$$

which is a simple quadratic with solutions $t = \pm0.31$ s. Use this time in Eq. 2-29 to find his speed when he hit ground,

$$v_y = (0) - (9.8\text{ m/s}^2)(0.31\text{ s}) = -3.1\text{ m/s}.$$

This becomes the initial velocity for the deceleration motion, so his average speed during deceleration is given by Eq. 2-27,

$$v_{\text{av},y} = \frac{1}{2}(v_y + v_{0y}) = \frac{1}{2}((0) + (-3.1 \text{ m/s})) = -1.6 \text{ m/s}.$$

This average speed, used with the distance of -2.2 cm (-0.022 m), can be used to find the time of deceleration

$$v_{\text{av},y} = \Delta y/\Delta t,$$

and putting numbers into the expression gives $\Delta t = 0.014$ s. Finally, we use this in Eq. 2-26 to find the acceleration,

$$(0) = (-3.1 \text{ m/s}) + a(0.014 \text{ s}),$$

which gives $a = 220 \text{ m/s}^2$.

(b) The average *net* force on the man is

$$\sum F_y = ma_y = (83\,\text{kg})(220\,\text{m/s}^2) = 1.8\times10^4\text{N}.$$

E3-24 The average speed of the salmon while decelerating is 4.6 ft/s. The time required to stop the salmon is then $t = x/v_{\text{av}} = (0.38 \text{ ft})/(4.6 \text{ ft/s}) = 8.3\times10^{-2}$s. The deceleration of the salmon is $a = \Delta v/\Delta t = (9.2 \text{ ft/s})/(8.2\text{-}2\text{s}) = 110 \text{ ft/s}^2$. The force on the salmon is then $F = Wa/g = (19 \text{ lb})(110 \text{ ft/s}^2)/(32 \text{ ft/s}^2) = 65$ lb.

$\boxed{\textbf{E3-25}}$ From appendix G we find 1 lb = 4.448 N; so the weight is (100 lb)(4.448 N/1 lb) = 445 N; similarly the cord will break if it pulls upward on the object with a force greater than 387 N. The mass of the object is $m = W/g = (445 \text{ N})/(9.8 \text{ m/s}^2) = 45$ kg.

There are two vertical forces on the 45 kg object, an upward force from the cord F_{OC} (which has a maximum value of 387 N) and a downward force from gravity F_{OG}. Then $\sum F_y = F_{OC} - F_{OG} = (387 \text{ N}) - (445 \text{ N}) = -58$ N. Since the net force is negative, the object must be accelerating downward according to

$$a_y = \sum F_y/m = (-58\,\text{N})/(45\,\text{kg}) = -1.3\,\text{m/s}^2.$$

E3-26 (a) Constant speed means no acceleration, hence no net force; this means the weight is balanced by the force from the scale, so the scale reads 65 N.

(b) Net force on mass is $F_{\text{net}} = ma = Wa/g = (65\,\text{N})(-2.4\,\text{m/s}^2)/(9.81\,\text{m/s}^2) = -16\,\text{N}$.. Since the weight is 65 N, the scale must be exerting a force of $(-16\,\text{N}) - (-65\,\text{N}) = 49\,\text{N}$.

E3-27 The magnitude of the net force is $W - R = (1600\,\text{kg})(9.81\,\text{m/s}^2) - (3700\,\text{N}) = 12000\,\text{N}$. The acceleration is then $a = F/m = (12000\,\text{N})/(1600\,\text{kg}) = 7.5\,\text{m/s}^2$. The time to fall is

$$t = \sqrt{2y/a} = \sqrt{2(-72\,\text{m})/(-7.5\,\text{m/s}^2)} = 4.4\,\text{s}.$$

The final speed is $v = at = (-7.5\,\text{m/s}^2)(4.4\,\text{s}) = 33\,\text{m/s}$. Get better brakes, eh?

E3-28 The average speed during the acceleration is 140 ft/s. The time for the plane to travel 300 ft is

$$t = x/v_{\text{av}} = (300 \text{ ft})/(140 \text{ ft/s}) = 2.14\,\text{s}.$$

The acceleration is then

$$a = \Delta v/\Delta t = (280 \text{ ft/s})/(2.14\,\text{s}) = 130 \text{ ft/s}^2.$$

The net force on the plane is $F = ma = Wa/g = (52000 \text{ lb})(130 \text{ ft/s}^2)/(32 \text{ ft/s}^2) = 2.1\times10^5$lb.

The force exerted by the catapult is then $2.1\times10^5\text{lb} - 2.4\times10^4 \text{ lb} = 1.86\times10^5$ lb.

E3-29 (a) The acceleration of a hovering rocket is 0, so the net force is zero; hence the thrust must equal the weight. Then $T = W = mg = (51000\,\text{kg})(9.81\,\text{m/s}^2) = 5.0\times10^5\text{N}$.

(b) If the rocket accelerates upward then the net force is $F = ma = (51000\,\text{kg})(18\,\text{m/s}^2) = 9.2\times10^5\,\text{N}$. Now $F_{\text{net}} = T - W$, so $T = 9.2\times10^5\,\text{N} + 5.0\times10^5\text{N} = 1.42\times10^6\text{N}$.

E3-30 (a) Net force on parachute + person system is $F_{\text{net}} = ma = (77\,\text{kg} + 5.2\,\text{kg})(-2.5\,\text{s}^2) = -210\,\text{N}$. The weight of the system is $W = mg = (77\,\text{kg}+5.2\,\text{kg})(9.81\,\text{s}^2) = 810\,\text{N}$. If P is the upward force of the air on the system (parachute) then $P = F_{\text{net}} + W = (-210\,\text{N}) + (810\,\text{N}) = 600\,\text{N}$.

(b) The net force on the *parachute* is $F_{\text{net}} = ma = (5.2\,\text{kg})(-2.5\,\text{s}^2) = -13\,\text{N}$. The weight of the parachute is $W = mg = (5.2\,\text{kg})(9.81\,\text{m/s}^2) = 51\,\text{N}$. If D is the downward force of the person on the parachute then $D = -F_{\text{net}} - W + P = -(-13\,\text{N}) - (51\,\text{N}) + 600\,\text{N} = 560\,\text{N}$.

$\boxed{\textbf{E3-31}}$ (a) The *total* mass of the helicopter+car system is 19,500 kg; and the only other force acting on the system is the force of gravity, which is

$$W = mg = (19,500\,\text{kg})(9.8\,\text{m/s}^2) = 1.91\times10^5\,\text{N}.$$

The force of gravity is directed down, so the net force on the system is $\sum F_y = F_{BA} - (1.91\times10^5$ N). The net force can also be found from Newton's second law: $\sum F_y = ma_y = (19,500$ kg)(1.4 m/s^2) $= 2.7\times10^4$ N. Equate the two expressions for the net force, $F_{BA} - (1.91\times10^5$ N) $= 2.7\times10^4$ N, and solve; $F_{BA} = 2.2\times10^5$ N.

(b) Repeat the above steps except: (1) the system will consist only of the car, and (2) the upward force on the car comes from the supporting cable only F_{CC}. The weight of the car is $W = mg = (4500$ kg)(9.8 m/s^2) $= 4.4\times10^4$ N. The net force is $\sum F_y = F_{CC} - (4.4\times10^4$ N), it can also be written as $\sum F_y = ma_y = (4500$ kg)(1.4 m/s^2) $= 6300$ N. Equating, $F_{CC} = 50,000$ N.

P3-1 (a) The acceleration is $a = F/m = (2.7\times10^{-5}\text{N})/(280\,\text{kg}) = 9.64\times10^{-8}\text{m/s}^2$. The displacement (from the original trajectory) is

$$y = at^2/2 = (9.64\times10^{-8}\text{m/s}^2)(2.4\,\text{s})^2/2 = 2.8\times10^{-7}\text{m}.$$

(b) The acceleration is $a = F/m = (2.7\times10^{-5}\text{N})/(2.1\,\text{kg}) = 1.3\times10^{-5}\text{m/s}^2$. The displacement (from the original trajectory) is

$$y = at^2/2 = (1.3\times10^{-5}\text{m/s}^2)(2.4\,\text{s})^2/2 = 3.7\times10^{-5}\text{m}.$$

P3-2 (a) The acceleration of the sled is $a = F/m = (5.2\,\text{N})/(8.4\,\text{kg}) = 0.62\,\text{m/s}^2$.

(b) The acceleration of the girl is $a = F/m = (5.2\,\text{N})/(40\,kg) = 0.13\,\text{m/s}^2$.

(c) The distance traveled by girl is $x_1 = a_1t^2/2$; the distance traveled by the sled is $x_2 = a_2t^2/2$. The two meet when $x_1 + x_2 = 15\,\text{m}$. This happens when $(a_1 + a_2)t^2 = 30\,\text{m}$. They then meet when $t = \sqrt{(30\,\text{m})/(0.13\,\text{m/s}^2 + 0.62\,\text{m/s}^2)} = 6.3\,\text{s}$. The girl moves $x_1 = (0.13\,\text{m/s}^2)(6.3\,\text{s})^2/2 = 2.6\,\text{m}$.

$\boxed{\textbf{P3-3}}$ (a) Start with block one. It starts from rest, accelerating through a distance of 16 m in a time of 4.2 s. Applying Eq. 2-28,

$$\begin{aligned} x &= x_0 + v_{0x}t + \frac{1}{2}a_xt^2, \\ -16\text{ m} &= (0) + (0)(4.2\text{ s}) + \frac{1}{2}a_x(4.2\text{ s})^2, \end{aligned}$$

find the acceleration to be $a_x = -1.8$ m/s^2.

Now for the second block. The acceleration of the second block is identical to the first for much the same reason that all objects fall with approximately the same acceleration.

(b) The initial and final velocities are related by a sign, then $v_x = -v_{0x}$ and Eq. 2-26 becomes

$$\begin{aligned} v_x &= v_{0x} + a_x t, \\ -v_{0x} &= v_{0x} + a_x t, \\ -2v_{0x} &= (-1.8 \text{ m/s}^2)(4.2 \text{ s}). \end{aligned}$$

which gives an initial velocity of $v_{0x} = 3.8$ m/s.

(c) Half of the time is spent coming down from the highest point, so the time to "fall" is 2.1 s. The distance traveled is found from Eq. 2-28,

$$x = (0) + (0)(2.1\,\text{s}) + \frac{1}{2}(-1.8\,\text{m/s}^2)(2.1\,\text{s})^2 = -4.0\,\text{m}.$$

P3-4 (a) The weight of the engine is $W = mg = (1400\,\text{kg})(9.81\,\text{m/s}^2) = 1.37\times10^4\,\text{N}$. If each bolt supports 1/3 of this, then the force on a bolt is 4600 N.

(b) If engine accelerates up at $2.60\,\text{m/s}^2$, then net force on the engine is

$$F_{\text{net}} = ma = (1400\,\text{kg})(2.60\,\text{m/s}^2) = 3.64\times10^3\,\text{N}.$$

The upward force from the bolts must then be

$$B = F_{\text{net}} + W = (3.64\times10^3\,\text{N}) + (1.37\times10^4\,\text{N}) = 1.73\times10^4\text{N}.$$

The force per bolt is one third this, or 5800 N.

P3-5 (a) If craft descends with constant speed then net force is zero, so thrust balances weight. The weight is then 3260 N.

(b) If the thrust is 2200 N the net force is $2200\,\text{N} - 3260\,\text{N} = -1060\,\text{N}$. The mass is then $m = F/a = (-1060\,\text{N})/(-0.390\,\text{m/s}^2) = 2720\,\text{kg}$.

(c) The acceleration due to gravity is $g = W/m = (3260\,\text{N})/(2720\,\text{kg}) = 1.20\,\text{m/s}^2$.

P3-6 The weight is originally Mg. The net force is originally $-Ma$. The upward force is then originally $B = Mg - Ma$. The goal is for a net force of $(M - m)a$ and a weight $(M - m)g$. Then

$$(M - m)a = B - (M - m)g = Mg - Ma - Mg + mg = mg - Ma,$$

or $m = 2Ma/(a + g)$.

$\boxed{\textbf{P3-7}}$ (a) Consider all three carts as one system. Then

$$\begin{aligned} \sum F_x &= m_{\text{total}} a_x, \\ 6.5 \text{ N} &= (3.1\,\text{kg} + 2.4\,\text{kg} + 1.2\,\text{kg})a_x, \\ 0.97 \text{ m/s}^2 &= a_x. \end{aligned}$$

(b) Now choose your system so that it only contains the third car. Then

$$\sum F_x = F_{23} = m_3 a_x = (1.2\,\text{kg})(0.97\,\text{m/s}^2).$$

The unknown can be solved to give $F_{23} = 1.2\,\text{N}$ directed to the right.

(c) Consider a system involving the second and third carts. Then $\sum F_x = F_{12}$, so Newton's law applied to the system gives

$$F_{12} = (m_2 + m_3)a_x = (2.4\,\text{kg} + 1.2\,\text{kg})(0.97\,\text{m/s}^2) = 3.5\,\text{N}.$$

P3-8 (a) $F = ma = (45.2\,\mathrm{kg} + 22.8\,\mathrm{kg} + 34.3\,\mathrm{kg})(1.32\,\mathrm{m/s^2}) = 135\,\mathrm{N}$.

(b) Consider only m_3. Then $F = ma = (34.3\,\mathrm{kg})(1.32\,\mathrm{m/s^2}) = 45.3\,\mathrm{N}$.

(c) Consider m_2 and m_3. Then $F = ma = (22.8\,\mathrm{kg} + 34.3\,\mathrm{kg})(1.32\,\mathrm{m/s^2}) = 75.4\,\mathrm{N}$.

P3-9 (c) The net force on each link is the same, $F_{\mathrm{net}} = ma = (0.100\,\mathrm{kg})(2.50\,\mathrm{m/s^2}) = 0.250\,\mathrm{N}$.

(a) The weight of each link is $W = mg = (0.100\,\mathrm{kg})(9.81\,\mathrm{m/s^2}) = 0.981\,\mathrm{N}$. On each link (except the top or bottom link) there is a weight, an upward force from the link above, and a downward force from the link below. Then $F_{\mathrm{net}} = U - D - W$. Then $U = F_{\mathrm{net}} + W + D = (0.250\,\mathrm{N}) + (0.981\,\mathrm{N}) + D = 1.231\,\mathrm{N} + D$. For the bottom link $D = 0$. For the bottom link, $U = 1.23\,\mathrm{N}$. For the link above, $U = 1.23\,\mathrm{N} + 1.23\,\mathrm{N} = 2.46\,\mathrm{N}$. For the link above, $U = 1.23\,\mathrm{N} + 2.46\,\mathrm{N} = 3.69\,\mathrm{N}$. For the link above, $U = 1.23\,\mathrm{N} + 3.69\,\mathrm{N} = 4.92\,\mathrm{N}$.

(b) For the top link, the upward force is $U = 1.23\,\mathrm{N} + 4.92\,\mathrm{N} = 6.15\,\mathrm{N}$.

P3-10 (a) The acceleration of the two blocks is $a = F/(m_1 + m_2)$ The net force on block 2 is from the force of contact, and is

$$P = m_2 a = F m_2/(m_1 + m_2) = (3.2\,\mathrm{N})(1.2\,\mathrm{kg})/(2.3\,\mathrm{kg} + 1.2\,\mathrm{kg}) = 1.1\,\mathrm{N}.$$

(b) The acceleration of the two blocks is $a = F/(m_1 + m_2)$ The net force on block 1 is from the force of contact, and is

$$P = m_1 a = F m_1/(m_1 + m_2) = (3.2\,\mathrm{N})(2.3\,\mathrm{kg})/(2.3\,\mathrm{kg} + 1.2\,\mathrm{kg}) = 2.1\,\mathrm{N}.$$

Not a third law pair, eh?

$\boxed{\textbf{P3-11}}$ (a) Treat the system as including both the block and the rope, so that the mass of the system is $M + m$. There is one (relevant) force which acts on the system, so $\sum F_x = P$. Then Newton's second law would be written as $P = (M + m)a_x$. Solve this for a_x and get $a_x = P/(M + m)$.

(b) Now consider only the block. The horizontal force doesn't act on the block; instead, there is the force of the rope on the block. We'll assume that force has a magnitude R, and this is the *only* (relevant) force on the block, so $\sum F_x = R$ for the net force on the block.. In this case Newton's second law would be written $R = Ma_x$. Yes, a_x is the same in part (a) and (b); the acceleration of the block is the same as the acceleration of the block + rope. Substituting in the results from part (a) we find

$$R = \frac{M}{M + m}P.$$