5 × (2) = 10
21 × (3) = 63
73

Solutions to Exercises

1. Yes. When a net force acts on an object, it is accelerated by an amount $\frac{F}{m}$. You can measure this acceleration by measuring the object's change in velocity over a time interval $\frac{\Delta v}{\Delta t}$. Note the consistency of units:

$$\text{SI units: } a = \frac{F}{m} = \frac{\text{N}}{\text{kg}} = \frac{\frac{\text{kg}\cdot\text{m}}{\text{s}^2}}{\text{kg}} = \frac{\text{m}}{\text{s}^2} = \frac{\frac{\text{m}}{\text{s}}}{\text{s}} = \frac{\Delta v}{\Delta t}$$

$$\text{English units: } a = \frac{F}{m} = \frac{\text{lb}}{\text{slug}} = \frac{\frac{\text{slug}\cdot\text{ft}}{\text{s}^2}}{\text{slug}} = \frac{\text{ft}}{\text{s}^2} = \frac{\frac{\text{ft}}{\text{s}}}{\text{s}} = \frac{\Delta v}{\Delta t}$$

2. Yes. Since weight is a gravitational force—$\vec{F}_g = m\vec{g}$—weight is directly proportional to the mass. Therefore, when the mass is doubled, the weight is doubled.

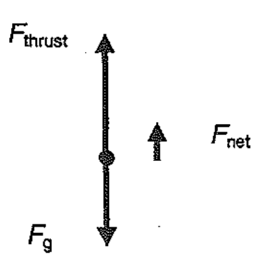
3. The coefficient of static friction for the two surfaces is greater than the coefficient of kinetic friction. Or, in other words, the electrical force of attraction between the surface of the book and the surface of the table is greater when the book is not moving. Thus, it requires more force to start the book moving than it does to keep it moving.

4. If no forces other than gravity are acting on the objects, both objects will hit the ground at the same time. Gravitational acceleration (g) is a constant. As the mass of the object increases, the gravitational force increases but the gravitational acceleration remains the same.

$a = \frac{\vec{F}_g}{m} = \frac{m\vec{g}}{m} = \vec{g}$

5. $g = \frac{F}{m} = \frac{\text{N}}{\text{kg}} = \frac{\frac{\text{kg}\cdot\text{m}}{\text{s}^2}}{\text{kg}} = \frac{\text{m}}{\text{s}^2}$

6. (a) $F_{net} = F_{thrust} - F_g = F_{thrust} - mg$



$$F_{\text{net}} = 3{,}110{,}000 \text{ N} - \left(232{,}000 \text{ kg} \times 9.80 \frac{\text{m}}{\text{s}^2}\right)$$

$$F_{\text{net}} = \boxed{8.34 \times 10^5 \text{ N}}$$

(b) $$a = \frac{F_{\text{net}}}{m} = \frac{8.34 \times 10^5 \text{ N}}{2.32 \times 10^5 \text{ kg}} = \frac{8.34 \times 10^5 \ \frac{\text{kg}\cdot\text{m}}{\text{s}^2}}{2.32 \times 10^5 \text{ kg}} = \boxed{3.59 \text{ m/s}^2}$$

(c) Newton's second law of motion states that the acceleration of an object is inversely proportional to the mass of the object. As the rocket fuel is consumed, the mass decreases. Thus, the acceleration increases. $\uparrow a = \frac{F}{m\downarrow}$

•• 7. (a) $$a = \frac{F_{\text{net}}}{m}$$

$$m = \frac{F_{\text{net}}}{a} = \frac{39 \text{ N}}{230 \frac{\text{m}}{\text{s}^2}} = \boxed{0.170 \text{ kg}}$$

(b) $$a = \frac{20 \text{ N}}{0.170 \text{ kg}} = \boxed{118 \frac{\text{m}}{\text{s}^2}}$$

•• 8. (a) $$F_{\text{static}} = \mu_{\text{static}} N = (0.35)\left(21 \text{ kg} \times 9.80 \frac{\text{m}}{\text{s}^2}\right) = \boxed{72 \text{ N}}$$

(b) $$F_{\text{kinetic}} = \mu_{\text{kinetic}} N = (0.28)\left(21 \text{ kg} \times 9.80 \frac{\text{m}}{\text{s}^2}\right) = \boxed{58 \text{ N}}$$

9. (a) $\boxed{9.80\ \frac{\text{m}}{\text{s}^2}}$

(b) $\boxed{0\ \frac{\text{m}}{\text{s}}}$

(c) $\boxed{9.80\ \frac{\text{m}}{\text{s}^2}}$

(d) $a = \frac{\Delta v}{\Delta t}$

$$\Delta v = v_f - v_i = v_f - 0 = v_f$$

$$\Delta v_f = a\,\Delta t = (9.80\ \frac{\text{m}}{\text{s}^2})(1\ \text{s}) = \boxed{9.8\ \frac{\text{m}}{\text{s}}}$$

10. (a) $N_{\text{tire}} = \frac{N_{\text{total}}}{4} = \frac{1460\ \text{kg} \times 9.80\ \frac{\text{m}}{\text{s}^2}}{4} = \boxed{3580\ \text{N}}$ 3,577

(b) Before the brakes lock, there is no sliding between tire and road. Use static friction.

$$F_{\text{static}} = \mu_{\text{static}} N = (0.75)(3580\ \text{N}) = \boxed{2700\ \text{N}}$$ 2,683

(c) If the brakes lock, there is sliding between the tire and road. Use kinetic friction.

$$F_{\text{kinetic}} = \mu_{\text{kinetic}} N = (0.60)(3580\ \text{N}) = \boxed{2100\ \text{N}}$$ 2,146

11. (a) As the mass increases, the normal force increases and the maximum braking force increases. $F = \mu N$

(b) The coefficient of friction for wet asphalt and a tire would be less than that for dry asphalt and a tire. Therefore, the maximum braking force decreases.

$F = \mu N$

12. (a) $N = Fg = mg = (53\text{ kg})(9.80\ \frac{\text{m}}{\text{s}^2}) = \boxed{520\text{ N}}$ upward perpendicular to the ice's surface.

(b) $F_{\text{kinetic}} = \mu_{\text{kinetic}} N = (0.15)(520\text{ N}) = \boxed{78\text{ N}}$. The force is parallel to the ice surface and opposite the direction of the skater's motion.

(c) $W = Fd = 78\text{ N} \times 35\text{ m} = 2700\text{ N}\cdot\text{m} = \boxed{2700\text{ J}}$

2730

13. $\cancel{m}g = G\frac{(m_{\text{Earth}})(\cancel{m})}{(r_{\text{Earth}})^2}$

$$\frac{1}{m} \times mg = G\frac{(m_{\text{Earth}})(m)}{(r_{\text{Earth}})^2} \times \frac{1}{m}$$

$$g = G\frac{(m_{\text{Earth}})}{(r_{\text{Earth}})^2}$$

Thus, g does not depend on your mass.

$$g = \left(6.67 \times 10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)\left[\frac{5.97 \times 10^{24}\text{ kg}}{(6.37 \times 10^6\text{ m})^2}\right]$$

$$g = \boxed{9.81\ \frac{\text{N}}{\text{kg}}} = \boxed{9.81\ \frac{\text{m}}{\text{s}^2}}$$