

CHAPTER 4 | *FORCES AND NEWTON'S LAWS OF MOTION*

ANSWERS TO FOCUS ON CONCEPTS QUESTIONS

- (b) If only one force acts on the object, it is the net force; thus, the net force must be nonzero. Consequently, the velocity would change, according to Newton's first law, and could not be constant.
- (d) This situation violates the first law, which predicts that the rabbit's foot tends to remain in place where it was when the car begins accelerating. The car would leave the rabbit's foot behind. That is, the rabbit's foot would swing away from, not toward, the windshield.
- (e) Newton's first law states that an object continues in a state of rest or in a state of motion at a constant speed along a straight line, unless compelled to change that state by a net force. All three statements are consistent with the first law.
- (a) Newton's second law with a net force of $7560\text{ N} - 7340\text{ N} = 220\text{ N}$ due north gives the answer directly.
- (c) Newton's second law gives the answer directly, provided the net force is calculated by vector addition of the two given forces. The direction of the net force gives the direction of the acceleration.
- (e) Newton's second law gives the answer directly. One method is to determine the total acceleration by vector addition of the two given components. The net force has the same direction as the acceleration.
- (e) Answers a and b are false, according to the third law, which states that whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body. It does not matter whether one of the bodies is stationary or whether it collapses. Answer c is false, because according to the third law, Sam and his sister experience forces of equal magnitudes during the push-off. Since Sam has the greater mass, he flies off with the smaller acceleration, according to the second law. Answer d is false, because in catching and throwing the ball each astronaut applies a force to it, and, according to the third law, the ball applies an oppositely directed force of equal magnitude to each astronaut. These reaction forces accelerate the astronauts away from each other, so that the distance between them increases.
- (b) Newton's third law indicates that Paul and Tom apply forces of equal magnitude to each other. According to Newton's second law, the magnitude of each of these forces is the mass times the magnitude of the acceleration. Thus, we have $m_{\text{Paul}}a_{\text{Paul}} = m_{\text{Tom}}a_{\text{Tom}}$, or
$$m_{\text{Paul}}/m_{\text{Tom}} = a_{\text{Tom}}/a_{\text{Paul}}$$

9. (e) Newton's law of gravitation gives the answer directly. According to this law the weight is directly proportional to the mass of the planet, so twice the mass means twice the weight. However, this law also indicates that the weight is inversely proportional to the square of the planet's radius, so three times the radius means one ninth the weight. Together, these two factors mean that the weight on the planet is $2/9$ or 0.222 times your earth-weight.
10. (c) Newton's law of gravitation gives the answer, provided that the distance between the centers of the spheres is used for r ($r = 0.50 \text{ m} + 1.20 \text{ m} + 0.80 \text{ m}$), rather than the distance between the surfaces of the spheres.
11. (a) The answer follows directly from the fact that weight W is given by $W = mg$, where m is the mass and g is the acceleration due to the earth's gravity. Thus, $m = (784 \text{ N})/(9.80 \text{ m/s}^2) = 80.0 \text{ kg}$. The mass is the same on Mercury as on Earth, because mass is an intrinsic property of matter.
12. (d) What matters is the direction of the elevator's acceleration. When the acceleration is upward, the apparent weight is greater than the true weight. When the acceleration is downward, the apparent weight is less than the true weight. In both possibilities the acceleration points upward.
13. (b) According to Newton's third law, the pusher and the wall exert forces of equal magnitude but opposite directions on each other. The normal force is the component of the wall's force that is perpendicular to the wall. Thus, it has the same magnitude as the component of the pusher's force that is perpendicular to the wall. As a result, the normal forces are ranked in the same order as the perpendicular components of the pusher's forces. The smallest perpendicular component is in B, and the largest is in C.
14. (a) The static frictional force is balancing the component of the block's weight that points down the slope of the incline. This component is smallest in B and greatest in A.
15. (b) The static frictional force that blocks A and B exert on each other has a magnitude f . The force that B exerts on A is directed to the right (the positive direction), while the force that A exerts on B is directed to the left. Blocks B and C also exert static frictional forces on each other, but these forces have a magnitude $2f$, because the normal force pressing B and C together is twice the normal force pressing A and B together. The force that C exerts on B is directed to the right, while the force that B exerts on C is directed to the left. In summary, then, block A experiences a single frictional force $+f$, which is the net frictional force; block B experiences two frictional forces, $-f$ and $+2f$, the net frictional force being $-f + 2f = +f$; block C experiences a single frictional force $+2f$, which is the net frictional force. It follows that $f_{s,A} = f_{s,B} = f_{s,C}/2$.
16. (c) The magnitude of the kinetic frictional force is proportional to the magnitude of the normal force. The normal force is smallest in B, because the vertical component of \mathbf{F} compensates for part of the block's weight. In contrast, the normal force is greatest in C, because the vertical component of \mathbf{F} adds to the weight of the block.

17. (d) Acceleration is inversely proportional to mass, according to Newton's second law. This law also indicates that acceleration is directly proportional to the net force. The frictional force is the net force acting on a block, and its magnitude is directly proportional to the magnitude of the normal force. However, in each of the pictures the normal force is directly proportional to the weight and, thus, the mass of a block. The inverse proportionality of the acceleration to mass and the direct proportionality of the net force to mass offset each other. The result is that the deceleration is the same in each case.
18. (e) In B the tension T is the smallest, because three rope segments support the weight W of the block, with the result that $3T = W$, or $T = W/3$. In A the tension is the greatest, because only one rope segment supports the weight of the block, with the result that $T = W$.
19. (c) Since the engines are shut down and since nothing is nearby to exert a force, the net force acting on the probe is zero, and its acceleration must be zero, according to Newton's second law. With zero acceleration the probe is in equilibrium.
20. (a) The hallmark of an object in equilibrium is that it has no acceleration. Therefore, an object in equilibrium need not be at rest. It can be moving with a constant velocity.
21. (b) Since the object is not in equilibrium, it must be accelerating. Newton's second law, in turn, implies that a net force must be present to cause the acceleration. Whether the net forces arises from a single force, two perpendicular forces, or three forces is not important, because only the net force appears in the second law.
22. (d) The block is at rest and, therefore, in equilibrium. According to Newton's second law, then, the net force acting on the block in a direction parallel to the inclined surface of the incline must be zero. This means that the force of static friction directed up the incline must balance the component of the block's weight directed down the incline
 $[(8.0 \text{ kg})(9.8 \text{ m/s}^2) \sin 22^\circ = 29 \text{ N}]$.
23. (b) Since the boxes move at a constant velocity, they have no acceleration and are, therefore, in equilibrium. According to Newton's second law, the net force acting on each box must be zero. Thus, Newton's second law applied to each box gives two equations in two unknowns, the magnitude of the tension in the rope between the boxes and the kinetic frictional force that acts on each box. Note that the frictional forces acting on the boxes are identical, because the boxes are identical. Solving these two equations shows that the tension is one-half of the applied force.
24. $31 \text{ kg}\cdot\text{m/s}^2$
25. 1030 N