Chapter 5 Answers

5.1 Section Review

1. Sample answer: (1) Gravitational forces are created between the Sun and Earth; (2) forces that move a soccer ball are created by your muscles when you kick the ball; and (3) forces that pull a thrown football toward the ground are created by gravity.
2. b
3. 5 pounds is a greater force.
4. B
5. Contact forces include friction, normal forces, and forces that involve ropes or springs. These forces involve two objects touching one another. Action-at-a-distance forces include gravity, magnetism, and electricity and involve interactions between objects that are not touching. The interacting objects have "fields" around them through which the interactions occur.
6. B
7. d
8. g = (9.8 N/kg) ÷ 6 = 1.63 N/kg
   W = mg = (100 kg)(1.63 N/kg) = 163 N
   The astronaut weighs 163 newtons.
9. W = mg = (3 kg)(9.8 N/kg) = 29.4 N

Study Skills

Using Force to Define Forces

friction: a force that resists motion.

normal force: the perpendicular force that a surface exerts on an object that is pressing on it.

spring force: a force that is exerted by a spring (a coil that resists being push or pulled).

Technology

Springs

Teaching tip: Before students begin to look for springs in their classroom, you may want to point out that the mechanical parts of a retractable pen include a spring (a compression spring). Bed frames and trampolines use extension springs.

Solve It!

1. 35 N ÷ 9.8 N/kg = 3.6 kg

2. 50 kg × 9.8 N/kg = 490 N
A mass of 50 kg is 450 N so it has more weight at Earth's surface than a 100-N object.

3. 0.5 kg × 9.8 N/kg = 4.9 N

5.2 Section Review

1. Oil is a liquid substance that helps reduce friction between the mechanical parts of car. Without oil, the friction between the mechanical parts would cause the car to overheat.
2. d
3. b
4. Sample answers: ball bearings in a bicycle; oil lubricant in a car; wheels (substituting the lower rolling friction for sliding friction)
5. Sample answers: the braking system on an elevator; using a "sticky" material like rubber on the end or bottom of an object (like a shoe); gymnasts use chalk on their hands to help them from slipping on the apparatus and ballerinas use rosin on their toe shoes to prevent slipping.
6. False. You can reduce friction with oil, but you cannot eliminate it.
7. D
8. False. Friction changes energy, it does not make it vanish. Friction may change the energy of a force into heat energy.
9. True. Electronic machines experience friction. Electricity moving through wires causes the wires to heat up. This is because of friction between the free electrons and the atoms in the wire.
10. Sample answer: Friction is caused by contact between objects and the resulting resistance to motion. The presence of water between two touching surfaces of objects will reduce friction between the object but water doesn't eliminate friction. When water runs over rocks it can cause the rocks to wear down (this is called physical weathering). Also, water can cause other small particles to bump again the rock so that it weathers more. Finally, water is also involved in the chemical weathering of rocks so that they break down even more.

Technology

Heat and Machines

Computers use an internal fan to cool off and reduce excess heat. Vacuum cleaners are able to remove heat by how they work—air passes over the mechanical parts and helps to cool them down. Cars remove heat in a variety of ways—coolant, oil, and air passing over engine parts helps to remove heat.

Journal

You Can Count on Friction!

Sample experiences with no friction: It would be hard to walk because feet or shoes on any surface would slip. Objects would be more likely to fall off of surfaces. Sample experiences with too much friction: More muscle energy would be required to push or slide objects. More energy would be required to get a car moving on a road because of the excessive friction between the tires and the road.

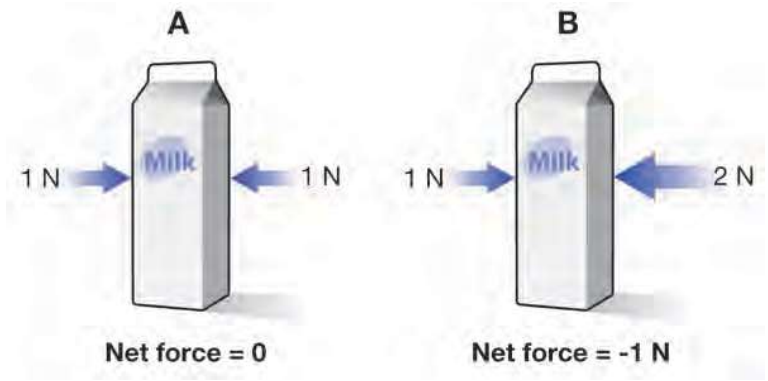
Challenge

Design A New Shoe!

Teaching tips: This challenge can be assigned as an individual or group project. Have students study their own favorite shoes to get ideas for what kinds of materials and details might be useful in their newly designed shoe.

5.3 Section Review

1. When all forces on an object are balanced forces then the net force on the object is zero.
2. Sample diagrams:



3. No, an accelerating object can have a positive or negative net force but never a zero net force. An acceleration object is either changing its velocity or direction so it is never in equilibrium.
4. The normal force supplied by the table would be 5 newtons.
5. net force = sum of all forces = 9 N + 6 N – 6 N = 9 N
6. a
7. Both forces are in the same direction: 150,000 N + 25,000 N = 175,000 N. The train's engine needs to produce 175,000 N in the opposite direction (uphill) for the train to be in equilibrium.
8. Diagram:

9. b
10. Each rope supports 1/2 the child's weight, so one rope has a tension of 100 N.

Connection

1. A person freely falling in an elevator feels weightless because the person accelerates downward at the same rate as the elevator. As a result, there is no support force on his or her feet, and the body feels weightless.
2. Astronauts in orbit are not truly weightless. Earth's gravity still pulls on their bodies. Astronauts are in free fall around the Earth. The spacecraft and astronauts fall with the same acceleration, so there is no support force, and the astronauts feel weightless.
3. Parabolic flights are used to train astronauts, to conduct scientific experiments, and for recreation.
4. I could demonstrate Newton's third law by floating, facing another person who is also floating, and pushing off of the person. We should feel equal forces and should both move backward.

Chapter 5 Assessment

Vocabulary

Section 5.1

1. force
2. pound
3. newton
4. weight
5. compression
6. tension

Section 5.2

7. friction
8. sliding friction
9. static friction

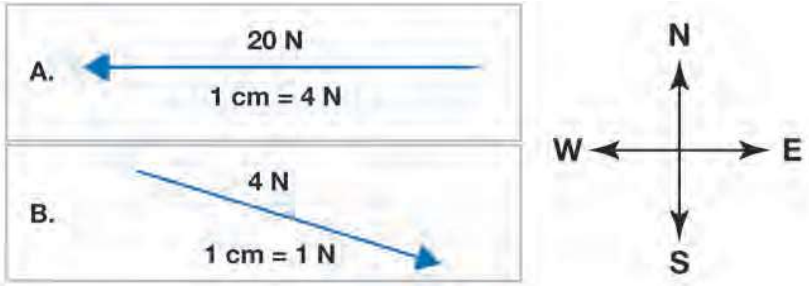
Section 5.3

10. balanced forces
11. equilibrium
12. normal force
13. free-body diagram
14. net force

Concepts

Section 5.1

1. Sample answers include: Earth's gravity creates a force that keeps us in place on the planet, muscles create forces for playing sports, and movement of air creates forces that cause sailboats to move.
2. strong, electromagnetic, weak, gravitational
3. Weight is a force because it is related to gravity. Gravity is one of the four elementary forces in the universe. Gravity pulls down on any object with mass giving it a weight. Weight is dependent on the strength of the gravitational pull.
4. Sample answer: Kicking a soccer ball changes the ball's direction and increases its speed.
5. To describe a force you need to know strength and direction.
6. Sample sketch:



7. Answer could include any one of the following for each type of force. Contact force: friction, applied, tension, normal, air resistance, spring Action-at-a-distance force: gravity, electricity, magnetism
8. The force increases proportionally to the amount the spring is stretched.
9. Tension, compression, and extension are all contact forces in that they involve two objects that are touching. Tension is a force created in a rope, for example, when it is pulled by a person or an object in two directions. Compression is a force created by a spring when it is pushed. Extension is a force, also created by a spring, when it is stretched out. Tension is different from compression or extension in that tension results in the transfer of forces or a change in their direction. Compression and extension forces are forces that are made or controlled by an object like a spring.
10. b
11. The mass of a person stays the same whether that person is on the Moon or on Earth. However, the Moon has less gravitational force so the weight of a person is less on the Moon than on Earth.
12. Answers:
    a. M
    b. F
    c. F
    d. M

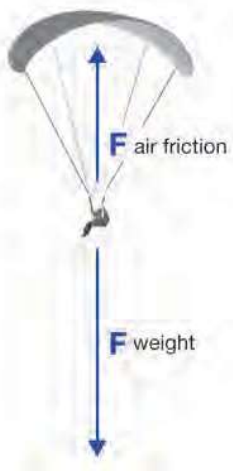
Section 5.2

13. Ice generally has very little friction when it is in contact with other materials for two reasons. First, it is relatively smooth, and has few bumps to cause friction. Second, there is usually a layer of low-friction water between the ice and the object sliding across it.
14. It requires more force to start an object moving because static friction is always greater than sliding friction at low speeds (such as the relatively slow speed of starting an object moving).
15. When the box is full of books, the tiny hills and valleys in the surfaces of the box and the floor are pressed together with a greater force than when then box is empty, so the amount of friction increases.
16. Possible sample answers: lubricating surfaces with oil; using ball bearings around a rotating shaft; separating two surfaces with a cushion of air; using magnetic levitation to separate two surfaces.
17. Friction keeps a nail in place because the wood around the nail pushes in on it, and when you try to pull the nail out, friction acts against the nail's motion.

18. Sample answers:
Heat energy – rubbing hands together transforms energy of motion to heat.
Mechanical – moving a key in and out of a lock wears away sharp points on a key.
19. We don't always want to reduce friction because sometimes friction is useful, for example, nails are held in place by friction, friction between wheels and brake pads stop vehicles, cleated shoes increase the friction between your foot and the ground.

Section 5.3

20. An object with a net force of zero can be moving with constant velocity.
21. Answers are:
    a. The ground exerts a normal force on you.
    b. The direction is upward, opposite that of gravity or weight.
    c. The strength of the normal force is equal to the force of gravity.
22. The race car is slowing down because the force backwards is greater than the force forward.
23. The forces acting on a plane are weight, lift, drag (air friction), and the thrust of the engine. To accelerate forward, the thrust must be bigger than the air friction force, and to stay in the air, the lift must equal the weight.
24. d. The normal force is always perpendicular to the surface. When the surface is slanted, the normal force is at an angle.
25. Diagram:



Problems

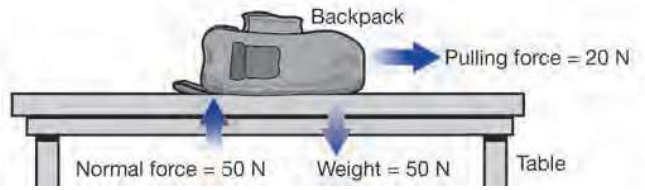
Section 5.1

1. 14.8 pounds
2. 49 N
3. 45 kg
4. 392 N
5. 5,103 kilograms
6. Her mass would still be 70 kg; her weight would be 259 N.
7. Diagrams:

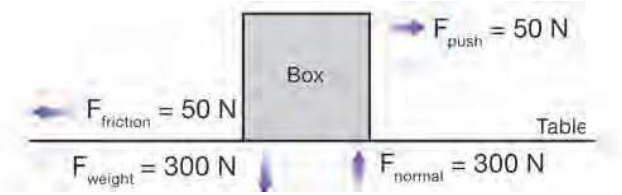
8. 20 cm
9. 10 N
10. Answers are:
    a. Each friend pulls with a force of 200 N, and the tension in the rope is 200 N.
    b. The single friend needs to pull with 200 N to get the same workout. The tension in this case is still 200 N, because the tree exerts a 200-N force making the net force equal to zero.
    c. In both cases above, the net force is zero.

Section 5.2

11. 150 N
12. Diagram:



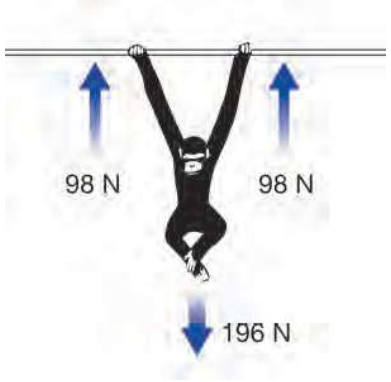
13. Diagram:



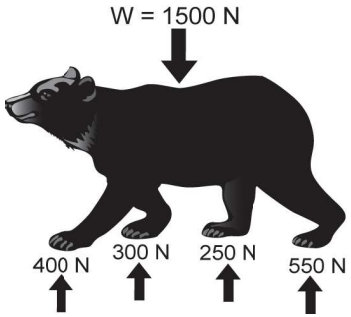
The box does not move in this situation because the friction force on it exactly opposes the pushing force.

Section 5.3

14. Answers are:
    a. 40 N left (or –40 N)
    b. 25 N up (or +25 N)
15. 20 kilograms is about 196 newtons.



16. The normal force is 9 newtons. To increase the normal force on the book you would need to push down on the book with your hand or place another book on top of the first book to increase the downward weight force.
17. If the 100 N force and the 200 N force are pointing in the same direction, and the 300 N force is pointed in the opposite direction, then the forces will be in equilibrium.
18. $F_{net} = 1500\text{ N} = 400\text{ N} + 300\text{ N} + 250\text{ N} + F_4$
    $F_4 = 550\text{ N}$
    The weight vector pushes down, the normal forces push up



Applying Your Knowledge

Section 5.1

1. The weight of my animal, a cat, is 10 pounds. Other answers:
   a. The mass of my cat is 4.54 kilograms.
   b. See table below.
   c. See table below.

COMPARING THE PROPERTIES OF THE PLANETS

Property	Mercury	Venus	Earth	Mars	Jupiter	Saturn
Gravitational force *(N/kg)*	3.7	8.9	9.8	3.7	23.1	9.0
My cat's weight *(N)*	16.8	40.4	44.5	16.8	105	40.9

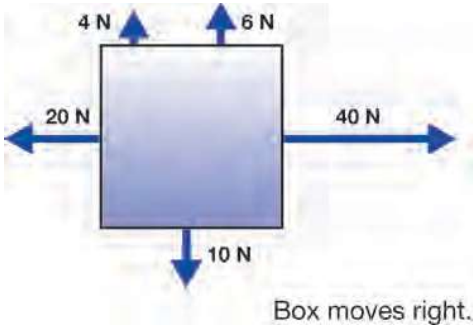
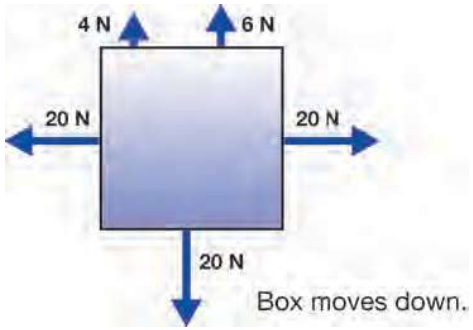
2. Answers:
   a. Sample answer: In general, there is a relationship between the amount of mass an object (like a planet) has and the strength of its gravitational force.
   b. Sample answer: No, there is not a clear trend between strength of gravitational force and the number of moons. For example, Mars has two moons and less gravitational force than Earth.
   c. Sample answer: No, there does not seem to be a trend that related the strength of gravitational force to distance from the Sun.
   d. Student answers will vary.

Section 5.2

3. The movement of the skates along solid ice is opposed by the force of sliding friction. When some ice melts, there is water between the skate and the ice. The liquid water acts as a lubricant and reduces friction between the blade of the skate and the ice so the skater easily glides.
4. Joints in the human body contain a lubricating fluid called synovial fluid. Like oil in an engine, this fluid reduces friction between the moving solid parts of the joint. This fluid has very unique properties because it acts like a liquid when the joint is moving slowly but like an elastic solid when the joint is moving quickly.
5. Answers:
   a. Weightlessness is the lack of a strong downward pulling force from gravity. Without this pull, the astronauts have trouble staying put on surfaces. In short, they lose the support of a normal force too! They can move from place to place in their space environment by using objects to pull on or push off of.
   b. In space, some muscles get weaker, and bones lose calcium. Balance and sleep are affected. Fluid in the body goes to different places than normal. Astronauts have to exercise to reduce the muscle and bone loss.

Section 5.3

6. Answers:
   a. This object is in equilibrium because the vertical forces and horizontal forces are balanced.
   b. Diagram:



   c. Diagram: