WARM-UP EXERCISES

WebAssign The warm-up exercises in this chapter may be assigned online in Enhanced WebAssign.

1. **Physics Review** A hockey player strikes a puck, giving it an initial velocity of 10.0 m/s in the positive *x*-direction. The puck slows uniformly to 6.00 m/s when it has traveled 40.0 m. (a) What is the puck's acceleration? (b) At what velocity is it traveling after 2.00 s? (c) How long does it take to travel 40.0 m? (See Section 2.5.)
2. Four forces act on an object, given by $\vec{\mathbf{A}} = 40.0$ N east, $\vec{\mathbf{B}} = 50.0$ N north, $\vec{\mathbf{C}} = 70.0$ N west, and $\vec{\mathbf{D}} = 90.0$ N south. (a) What is the magnitude of the net force on the object? (b) What is the direction of the force? (See Sections 3.2 and 4.3.)
3. A force of 30.0 N is applied in the positive *x*-direction to a block of mass 8.00 kg, at rest on a frictionless surface. (a) What is the block's acceleration? (b) How fast is it going after 6.00 s? (See Sections 2.5 and 4.3.)
4. What would be the acceleration of gravity at the surface of a world with twice Earth's mass and twice its radius? (See Section 4.3.)
5. Two monkeys are holding onto a single vine of negligible mass that hangs vertically from a tree, with one monkey a few meters higher than the other. The upper monkey has mass 20.0 kg and the lower monkey mass 10.0 kg. What is the ratio of the tension in the vine above the upper monkey to the tension in the vine between the two monkeys? (See Section 4.5.)
6. Two identical strings making an angle of $\theta = 30.0°$ with respect to the vertical support a block of mass $m = 15.0$ kg (Figure WU4.6). What is the tension in each of the strings? (See Section 4.5.)

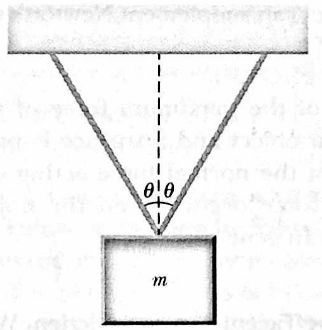


Figure WU4.6

7. Calculate the normal force on a 15.0 kg block in the following circumstances: (a) The block is resting on a level surface. (b) The block is resting on a surface tilted up at a 30.0° angle with respect to the horizontal. (c) The block is resting on the floor of an elevator that is accelerating upwards at 3.00 m/s^2. (d) The block is on a level surface and a force of 125 N is exerted on it at an angle of 30.0° above the horizontal. (See Section 4.5.)
8. A horizontal force of 95.0 N is applied to a 60.0-kg crate on a rough, level surface. If the crate accelerates at 1.20 m/s^2, what is the magnitude of the force of kinetic friction acting on the crate? (See Section 4.5.)
9. A car of mass 875 kg is traveling 30.0 m/s when the driver applies the brakes, which lock the wheels. The car skids for 5.60 s in the positive *x*-direction before coming to rest. (a) What is the car's acceleration? (b) What magnitude force acted on the car during this time? (c) How far did the car travel? (See Sections 2.5 and 4.5.)
10. A block of mass 12.0 kg is sliding at an initial velocity of 8.00 m/s in the positive *x*-direction. The surface has a coefficient of kinetic friction of 0.300. (a) What is the force of kinetic friction acting on the block? (b) What is the block's acceleration? (c) How far will it slide before coming to rest? (See Sections 2.5 and 4.6.)
11. A man exerts a horizontal force of 112 N on a refrigerator of mass 42.0 kg. If the refrigerator doesn't move, what is the minimum coefficient of static friction between the refrigerator and the floor? (See Section 4.6.)
12. An Atwood's machine (Figure 4.20) consists of two masses, one of mass 3.00 kg and the other of mass 8.00 kg. When released from rest, what is the acceleration of the system? (See Section 4.6.)
13. A block of mass $m_1 = 16$ kg is on a frictionless table to the left of a second block of mass $m_2 = 24$ kg, attached by a horizontal string (Figure WU4.13). If a horizontal force of 120 N is exerted on the block m_2 in the positive *x*-direction, (a) use the system approach to find the acceleration of the two blocks. (b) What is the tension in the string connecting the blocks? (See Section 4.6.)

Figure WU4.13

CONCEPTUAL QUESTIONS

WebAssign The conceptual questions in this chapter may be assigned online in Enhanced WebAssign.

1. A passenger sitting in the rear of a bus claims that she was injured as the driver slammed on the brakes, causing a suitcase to come flying toward her from the front of the bus. If you were the judge in this case, what disposition would you make? Explain.
2. A space explorer is moving through space far from any planet or star. He notices a large rock, taken as a specimen from an alien planet, floating around the cabin of the ship. Should he push it gently, or should he kick it toward the storage compartment? Explain.

3. (a) If gold were sold by weight, would you rather buy it in Denver or in Death Valley? (b) If it were sold by mass, in which of the two locations would you prefer to buy it? Why?

4. If you push on a heavy box that is at rest, you must exert some force to start its motion. Once the box is sliding, why does a smaller force maintain its motion?

5. A ball is held in a person's hand. (a) Identify all the external forces acting on the ball and the reaction to each. (b) If the ball is dropped, what force is exerted on it while it is falling? Identify the reaction force in this case. (Neglect air resistance.)

6. A weight lifter stands on a bathroom scale. (a) As she pumps a barbell up and down, what happens to the reading on the scale? (b) Suppose she is strong enough to actually *throw* the barbell upward. How does the reading on the scale vary now?

7. (a) What force causes an automobile to move? (b) A propeller-driven airplane? (c) A rowboat?

8. If only one force acts on an object, can it be in equilibrium? Explain.

9. In the motion picture *It Happened One Night* (Columbia Pictures, 1934), Clark Gable is standing inside a stationary bus in front of Claudette Colbert, who is seated. The bus suddenly starts moving forward and Clark falls into Claudette's lap. Why did this happen?

10. Analyze the motion of a rock dropped in water in terms of its speed and acceleration as it falls. Assume a resistive force is acting on the rock that increases as the velocity of the rock increases.

11. Identify the action–reaction pairs in the following situations: (a) a man takes a step, (b) a snowball hits a girl in the back, (c) a baseball player catches a ball, (d) a gust of wind strikes a window.

12. Draw a free-body diagram for each of the following objects: (a) a projectile in motion in the presence of air resistance, (b) a rocket leaving the launch pad with its engines operating, (c) an athlete running along a horizontal track.

13. In a tug-of-war between two athletes, each pulls on the rope with a force of 200 N. What is the tension in the rope? If the rope doesn't move, what horizontal force does each athlete exert against the ground?

14. Suppose you are driving a car at a high speed. Why should you avoid slamming on your brakes when you want to stop in the shortest possible distance? (Newer cars have antilock brakes that avoid this problem.)

15. As a block slides down a frictionless incline, which of the following statements is true? (a) Both its speed and acceleration increase. (b) Its speed and acceleration remain constant. (c) Its speed increases and its acceleration remains constant. (d) Both its speed and acceleration decrease. (e) Its speed increases and its acceleration decreases.

16. A crate remains stationary after it has been placed on a ramp inclined at an angle with the horizontal. Which of the following statements must be true about the magnitude of the frictional force that acts on the crate? (a) It is larger than the weight of the crate. (b) It is at least equal to the weight of the crate. (c) It is equal to $\mu_s n$. (d) It is greater than the component of the gravitational force acting down the ramp. (e) It is equal to the component of the gravitational force acting down the ramp.

17. In the photo on page 91, a locomotive has broken through the wall of a train station. During the collision, what can be said about the force exerted by the locomotive on the wall? (a) The force exerted by the locomotive on the wall was larger than the force the wall could exert on the locomotive. (b) The force exerted by the locomotive on the wall was the same in magnitude as the force exerted by the wall on the locomotive. (c) The force exerted by the locomotive on the wall was less than the force exerted by the wall on the locomotive. (d) The wall cannot be said to "exert" a force; after all, it broke.

18. If an object is in equilibrium, which of the following statements is not true? (a) The speed of the object remains constant. (b) The acceleration of the object is zero. (c) The net force acting on the object is zero. (d) The object must be at rest. (e) The velocity is constant.

19. A truck loaded with sand accelerates along a highway. The driving force on the truck remains constant. What happens to the acceleration of the truck as its trailer leaks sand at a constant rate through a hole in its bottom? (a) It decreases at a steady rate. (b) It increases at a steady rate. (c) It increases and then decreases. (d) It decreases and then increases. (e) It remains constant.

20. A large crate of mass m is placed on the back of a truck but not tied down. As the truck accelerates forward with an acceleration a, the crate remains at rest relative to the truck. What force causes the crate to accelerate forward? (a) the normal force (b) the force of gravity (c) the force of friction between the crate and the floor of the truck (d) the "ma" force (e) none of these

21. Which of the following statements are true? (a) An astronaut's weight is the same on the Moon as on Earth. (b) An astronaut's mass is the same on the International Space Station as it is on Earth. (c) Earth's gravity has no effect on astronauts inside the International Space Station. (d) An astronaut's mass is greater on Earth than on the Moon. (e) None of these statements are true.

PROBLEMS

WebAssign The problems in this chapter may be assigned online in Enhanced WebAssign.

1. denotes straightforward problem; **2.** denotes intermediate problem; **3.** denotes challenging problem

[1.] denotes full solution available in *Student Solutions Manual/Study Guide*

1. denotes problems most often assigned in Enhanced WebAssign

BIO denotes biomedical problems

GP denotes guided problems

M denotes Master It tutorial available in Enhanced WebAssign

Q|C denotes asking for quantitative and conceptual reasoning

S denotes symbolic reasoning problem

W denotes Watch It video solution available in Enhanced WebAssign

4.1 Forces

4.2 Newton's First Law

4.3 Newton's Second Law

4.4 Newton's Third Law

1. The heaviest invertebrate is the giant squid, which is estimated to have a weight of about 2 tons spread out over its length of 70 feet. What is its weight in newtons?

2. A football punter accelerates a football from rest to a speed of 10 m/s during the time in which his toe is in contact with the ball (about 0.20 s). If the football has a mass of 0.50 kg, what average force does the punter exert on the ball?

3. A 6.0-kg object undergoes an acceleration of 2.0 m/s^2. (a) What is the magnitude of the resultant force acting on it? (b) If this same force is applied to a 4.0-kg object, what acceleration is produced?

4. **Q|C** One or more external forces are exerted on each object enclosed in a dashed box shown in Figure 4.2. Identify the reaction to each of these forces.

5. A bag of sugar weighs 5.00 lb on Earth. What would it weigh in newtons on the Moon, where the free-fall acceleration is one-sixth that on Earth? Repeat for Jupiter, where g is 2.64 times that on Earth. Find the mass of the bag of sugar in kilograms at each of the three locations.

6. A freight train has a mass of 1.5×10^7 kg. If the locomotive can exert a constant pull of 7.5×10^5 N, how long does it take to increase the speed of the train from rest to 80 km/h?

7. A 75-kg man standing on a scale in an elevator notes that as the elevator rises, the scale reads 825 N. What is the acceleration of the elevator?

8. **Q|C** Consider a solid metal sphere (S) a few centimeters in diameter and a feather (F). For each quantity in the list that follows, indicate whether the quantity is the same, greater, or lesser in the case of S or in that of F. Explain in each case why you gave the answer you did. Here is the list: (a) the gravitational force, (b) the time it will take to fall a given distance in air, (c) the time it will take to fall a given distance in vacuum, (d) the total force on the object when falling in vacuum.

[9.] **BIO** As a fish jumps vertically out of the water, assume that only two significant forces act on it: an upward force F exerted by the tail fin and the downward force due to gravity. A record Chinook salmon has a length of 1.50 m and a mass of 61.0 kg. If this fish is moving upward at 3.00 m/s as its head first breaks the surface and has an upward speed of 6.00 m/s after two-thirds of its length has left the surface, assume constant acceleration and determine (a) the salmon's acceleration and (b) the magnitude of the force F during this interval.

10. **W** A 5.0-g bullet leaves the muzzle of a rifle with a speed of 320 m/s. What force (assumed constant) is exerted on the bullet while it is traveling down the 0.82-m-long barrel of the rifle?

11. A boat moves through the water with two forces acting on it. One is a 2 000-N forward push by the water on the propeller, and the other is a 1 800-N resistive force due to the water around the bow. (a) What is the acceleration of the 1 000-kg boat? (b) If it starts from rest, how far will the boat move in 10.0 s? (c) What will its velocity be at the end of that time?

12. Two forces are applied to a car in an effort to move it, as shown in Figure P4.12. (a) What is the resultant vector of these two forces? (b) If the car has a mass of 3 000 kg, what acceleration does it have? Ignore friction.

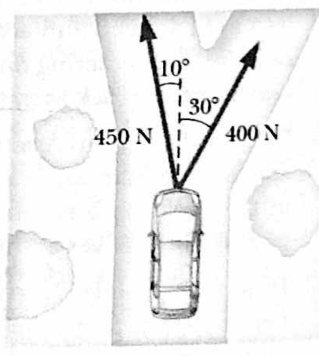


Figure P4.12

13. A 970-kg car starts from rest on a horizontal roadway and accelerates eastward for 5.00 s when it reaches a speed of 25.0 m/s. What is the average force exerted on the car during this time?

14. **S** An object of mass m is dropped from the roof of a building of height h. While the object is falling, a wind blowing parallel to the face of the building exerts a constant horizontal force F on the object. (a) How long does it take the object to strike the ground? Express the time t in terms of g and h. (b) Find an expression in terms of m and F for the acceleration a_x of the object in the horizontal direction (taken as the positive x-direction). (c) How far is the object displaced horizontally before hitting the ground? Answer in terms of m, g, F, and h. (d) Find the magnitude of the object's acceleration while it is falling, using the variables F, m, and g.

9.7 Fluids in Motion

Certain aspects of a fluid in motion can be understood by assuming the fluid is nonviscous and incompressible and that its motion is in a steady state with no turbulence:

1. The flow rate through the pipe is a constant, which is equivalent to stating that the product of the cross-sectional area A and the speed v at any point is constant. At any two points, therefore, we have

$$A_1 v_1 = A_2 v_2 \qquad [9.15]$$

This relation is referred to as the **equation of continuity.**

2. The sum of the pressure, the kinetic energy per unit volume, and the potential energy per unit volume is the same at any two points along a streamline:

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2 \qquad [9.16]$$

Equation 9.16 is known as **Bernoulli's equation.** Solving problems with Bernoulli's equation is similar to solving problems with the work–energy theorem, whereby two points are chosen, one point where a quantity is unknown and another where all quantities are known. Equation 9.16 is then solved for the unknown quantity.

WARM-UP EXERCISES

ENHANCED WebAssign The warm-up exercises in this chapter may be assigned online in Enhanced WebAssign.

1. **Physics Review** A soap bubble hovers motionlessly in the air. If the soap bubble's mass, including the air inside it, is 2.00×10^{-4} kg determine the magnitude of the upward force acting on it. (See Section 4.5.)

2. **Physics Review** A team of huskies performs 7 440 J of work on a loaded sled of mass 124 kg, drawing it from rest up a 4.60-m high snow-covered rise while the sled loses 1 520 J due to friction. (a) What is the net work done on the sled by the huskies and friction? (b) What is the change in the sled's potential energy? (c) What is the speed of the sled at the top of the rise? (See Section 5.5.)

3. A 66.0-kg man lies on his back on a bed of nails, with 1 208 of the nails in contact with his body. The end of each nail has area 1.00×10^{-6} m^2. What average pressure is exerted by each nail on the man's body? (See Section 9.2.)

4. What is the mass of a solid gold rectangular bar that has dimensions of 4.50 cm × 11.0 cm × 26.0 cm? (See Section 9.2.)

5. Humans can bite with a force of approximately 800 N. If a human tooth has the Young's modulus of bone, a cross-sectional area of 1.0 cm^2, and is 2.0 cm long, determine the change in the tooth's length during an 8.0×10^2 N bite. (See Section 9.3.)

6. A hydraulic jack has an input piston of area 0.050 m^2 and an output piston of area 0.70 m^2. How much force on the input piston is required to lift a car weighing 1.2×10^4 N? (See Section 9.4.)

7. What is the pressure at the very bottom of Loch Ness, which is 754 ft deep? (Assume an air pressure of 1.013×10^5 Pa.) (See Section 9.4.)

8. The mercury in the sealed, evacuated tube of a barometer is 724 mm higher than the level of mercury exposed to the ambient air pressure. Calculate the ambient air pressure, P_0. (See Figure 9.17b.) (See Section 9.5.)

9. A 20.0-kg lead mass rests on the bottom of a pool. (a) What is the volume of the lead? (b) What buoyant force acts on the lead? (c) Find the lead's weight. (d) What is the normal force acting on the lead? (See Section 9.6.)

10. A horizontal pipe narrows from a radius of 0.250 m to 0.100 m. If the speed of the water in the pipe is 1.00 m/s in the larger-radius pipe, what is the speed in the smaller pipe? (See Section 9.7.)

11. A large water tank is 3.00 m high and filled to the brim, the top of the tank open to the air. A small pipe with a faucet is attached to the side of the tank, 0.800 m above the ground. If the valve is opened, at what speed will water come out of the pipe? (See Section 9.7.)

CONCEPTUAL QUESTIONS

ENHANCED WebAssign The conceptual questions in this chapter may be assigned online in Enhanced WebAssign.

1. A woman wearing high-heeled shoes is invited into a home in which the kitchen has vinyl floor covering. Why should the homeowner be concerned?

2. The density of air is 1.3 kg/m^3 at sea level. From your knowledge of air pressure at ground level, estimate the height of the atmosphere. As a simplifying assumption, take the atmosphere to be of uniform density up to some height, after which the density rapidly falls to zero. (In reality, the density of the atmosphere decreases as we go up.) (This question is courtesy of Edward F. Redish. For more questions of this type, see http://www.physics.umd.edu/perg/.)

3. Why do baseball home run hitters like to play in Denver, but curveball pitchers do not?

4. Figure CQ9.4 shows aerial views from directly above two dams. Both dams are equally long (the vertical dimension in the diagram) and equally deep (into the page in the diagram). The dam on the left holds back a very large lake, while the dam on the right holds back a narrow river. Which dam has to be built more strongly?

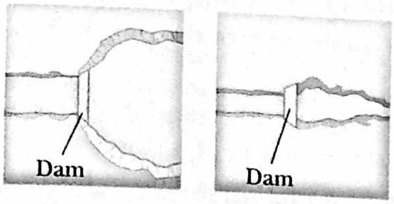
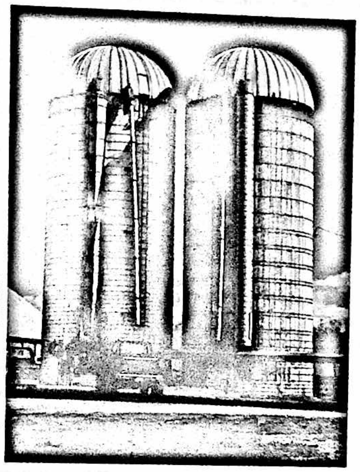


Figure CQ9.4

5. A typical silo on a farm has many bands wrapped around its perimeter, as shown in Figure CQ9.5. Why is the spacing between successive bands smaller at the lower portions of the silo?



Henry Leap and Jim Lehman

Figure CQ9.5

6. Many people believe that a vacuum created inside a vacuum cleaner causes particles of dirt to be drawn in. Actually, the dirt is pushed in. Explain.
7. Suppose a damaged ship just barely floats in the ocean after a hole in its hull has been sealed. It is pulled by a tugboat toward shore and into a river, heading toward a dry dock for repair. As the boat is pulled up the river, it sinks. Why?
8. **BIO** During inhalation, the pressure in the lungs is slightly less than external pressure and the muscles controlling exhalation are relaxed. Under water, the body equalizes internal and external pressures. Discuss the condition of the muscles if a person under water is breathing through a snorkel. Would a snorkel work in deep water?
9. The water supply for a city is often provided from reservoirs built on high ground. Water flows from the reservoir, through pipes, and into your home when you turn the tap on your faucet. Why is the water flow more rapid out of a faucet on the first floor of a building than in an apartment on a higher floor?
10. An ice cube is placed in a glass of water. What happens to the level of the water as the ice melts?
11. Place two cans of soft drinks, one regular and one diet, in a container of water. You will find that the diet drink floats while the regular one sinks. Use Archimedes' principle to devise an explanation. *Broad Hint:* The artificial sweetener used in diet drinks is less dense than sugar.
12. Will an ice cube float higher in water or in an alcoholic beverage?
13. Tornadoes and hurricanes often lift the roofs of houses. Use the Bernoulli effect to explain why. Why should you keep your windows open under these conditions?
14. Once ski jumpers are airborne (Fig. CQ9.14), why do they bend their bodies forward and keep their hands at their sides?

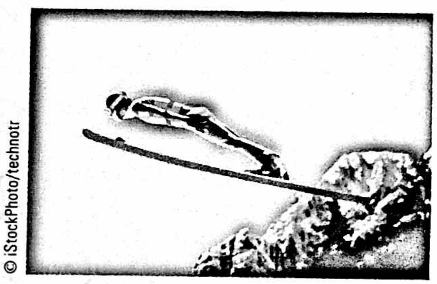


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Figure CQ9.14

15. A person in a boat floating in a small pond throws an anchor overboard. What happens to the level of the pond? (a) It rises. (b) It falls. (c) It remains the same.
16. One of the predicted problems due to global warming is that ice in the polar ice caps will melt and raise sea levels everywhere in the world. Is that more of a worry for ice (a) at the north pole, where most of the ice floats on water; (b) at the south pole, where most of the ice sits on land; (c) both at the north and south poles equally; or (d) at neither pole?

PROBLEMS

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SUMMARY

15.1 Properties of Electric Charges

Electric charges have the following properties:

1. Unlike charges attract one another and like charges repel one another.
2. Electric charge is always conserved.
3. Charge comes in discrete packets that are integral multiples of the basic electric charge $e = 1.6 \times 10^{-19}$ C.
4. The force between two charged particles is proportional to the inverse square of the distance between them.

15.2 Insulators and Conductors

Conductors are materials in which charges move freely in response to an electric field. All other materials are called **insulators.**

15.3 Coulomb's Law

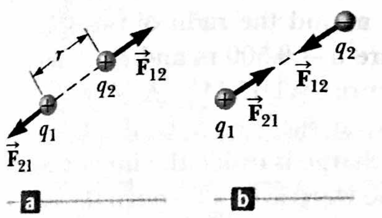
Coulomb's law states that the electric force between two stationary charged particles separated by a distance r has the magnitude

$$F = k_e \frac{|q_1||q_2|}{r^2} \quad [15.1]$$

where $|q_1|$ and $|q_2|$ are the magnitudes of the charges on the particles in coulombs and

$$k_e \approx 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \quad [15.2]$$

is the **Coulomb constant.**



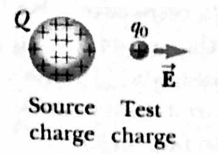
(a) The electric force between two charges with the same sign is repulsive, and (b) it is attractive when the charges have opposite signs.

15.4 The Electric Field

An electric field $\vec{E}$ exists at some point in space if a small test charge q_0 placed at that point is acted upon by an electric force $\vec{F}$. The electric field is defined as

$$\vec{E} \equiv \frac{\vec{F}}{q_0} \quad [15.3]$$

The **direction** of the electric field at a point in space is defined to be the direction of the electric force that would be exerted on a small positive charge placed at that point.



The electric force of charge Q on a test charge q_0 divided by q_0 gives the electric field $\vec{E}$ of Q at that point.

The magnitude of the electric field due to a *point charge* q at a distance r from the point charge is

$$E = k_e \frac{|q|}{r^2} \quad [15.6]$$

15.5 Electric Field Lines

Electric field lines are useful for visualizing the electric field in any region of space. The electric field vector $\vec{E}$ is tangent to the electric field lines at every point. Further, the number of electric field lines per unit area through a surface perpendicular to the lines is proportional to the strength of the electric field at that surface.

15.6 Conductors in Electrostatic Equilibrium

A **conductor in electrostatic equilibrium** has the following properties:

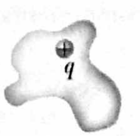
1. The electric field is zero everywhere inside the conducting material.
2. Any excess charge on an isolated conductor must reside entirely on its surface.
3. The electric field just outside a charged conductor is perpendicular to the conductor's surface.
4. On an irregularly shaped conductor, charge accumulates where the radius of curvature of the surface is smallest, at sharp points.

15.9 Electric Flux and Gauss's Law

Gauss's law states that the electric flux through any closed surface is equal to the net charge Q inside the surface divided by the permittivity of free space, ϵ_0:

$$EA = \Phi_E = \frac{Q_{\text{inside}}}{\epsilon_0} \quad [15.12]$$

For highly symmetric distributions of charge, Gauss's law can be used to calculate electric fields.



The electric flux Φ through any arbitrary surface surrounding a charge q is q/ϵ_0.

WARM-UP EXERCISES

WebAssign The warm-up exercises in this chapter may be assigned online in Enhanced WebAssign.

1. **Math Review** A force vector has components given by $F_x = -7.00$ N and $F_y = 4.50$ N. Find (a) the magnitude and (b) the direction of the force, measured counterclockwise from the positive x-axis.

2. **Math Review** The force acting on a particle has a magnitude of 125 N and is directed 30.0° above the positive x-axis. Determine (a) the x-component and (b) y-component of the force.

3. **Math Review** Two electric force vectors act on a particle. Their x-components are 15.0 N and −7.50 N and their y-components are −11.5 N and −4.50 N, respectively. For the resultant electric force, find (a) the x-component, (b) the y-component, and the (c) magnitude and (d) direction of the resultant electric force, measured counterclockwise from the positive x-axis. (See also Section 15.4.)

4. **Physics Review** A large firecracker explodes under a soda can, sending it straight upward with an initial speed of 7.27 m/s. Neglecting air friction, find (a) the can's maximum height, (b) the first time at which it reaches a height of 1.00 m, and (c) the velocity at that time. (See Section 2.5.)

5. **Physics Review** A simple pendulum with mass 0.250 kg hangs from string 1.40 m long. (See Fig. WU15.5.) A leaf blower blows air at it, exerting a constant horizontal drag force $\vec{F}_{drag}$ of magnitude 1.67 N. Find (a) the tension in the string and (b) the angle the pendulum makes with respect to the vertical. (See Section 4.5.)

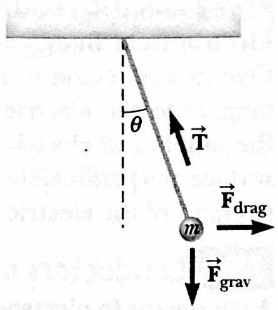


Figure WU15.5

6. **Physics Review** The Falcon 9 rocket, manufactured by the commercial SpaceX Corporation, has a takeoff mass of 4.80×10^5 kg and an initial thrust of 5.88×10^6 N. At takeoff, determine (a) the net upward force acting on the rocket, and (b) the upward acceleration of the rocket. (See Section 4.5.)

7. **Physics Review** A horizontal spring with force constant $k = 57.0$ N/m is used to accelerate a 0.500-kg mass on a frictionless surface. If the spring is compressed by 5.00×10^{-2} m and released, find (a) the initial magnitude of the spring force when the mass is released and (b) the initial acceleration of the mass. (See Section 5.4.)

8. Two protons are separated by a distance of 0.100 m. Given the proton charge of 1.60×10^{-19} C, determine the magnitude of the electric force that one proton exerts on the other. (See Section 15.3.)

9. A charge of 16.0 nC is located at the origin. Find (a) the magnitude and (b) the direction of the displacement vector pointing from the origin to (3.00, 4.00) m. Calculate (c) the magnitude, and (d) the x- and (e) y-components of the electric field at that point. (See Section 15.4.)

10. Consider a system of two charges where the first charge is on the positive x-axis and the second charge is on the positive y-axis. If these two charges produce electric fields at the origin given by (2.50, 0) N/C and (0, −2.50) N/C, respectively, determine (a) the magnitude and (b) the direction of the resultant electric field at the origin, measured counterclockwise from the positive x-axis. (c) What would be the magnitude of the force on a 1.41×10^{-9} C charge placed at the origin? (See Sections 15.3 and 15.4.)

11. A tiny droplet of oil of mass 1.50×10^{-15} kg having a charge of -2.56×10^{-18} C accelerates straight down inside a vacuum chamber. If the electric field is −5 625 N/C, find (a) the force of gravity on the droplet, (b) the electric force, and (c) the droplet's acceleration. (Give the correct signs, with down the negative direction.)

12. A constant electric field of magnitude 5.00 N/C and pointing in the positive z-direction passes through a square with sides of length 0.500 m, located in the xy-plane. (a) Calculate the magnitude of the electric flux through the square. (b) Repeat the calculation if the electric field is oriented at an angle of 30.0° with respect to the positive z-direction. (See Section 15.9.)

13. Three charges are placed inside a basketball. If the charges are 2.50 nC, −1.25 nC and 0.500 nC, respectively, what is the electric flux through the basketball? (See Section 15.9.)

14. A thin, hollow sphere has a charge $q = -2.00$ nC evenly distributed over its surface. The radius of the charged sphere is 1.00 m and the radii of two spherical Gaussian surfaces are $a = 0.500$ m and $b = 1.50$ m, respectively. (See Figure WU15.14.) A charge of $Q = 5.00$ nC is placed at the center of the charged sphere. (a) How much charge is inside the inner Gaussian surface? (b) Find the electric flux through the inner Gaussian surface, and (c) the electric field there, by dividing by the sphere's area. (d) How much charge is inside the outer dashed sphere? Find (e) the electric flux through the outer Gaussian surface and (f) the electric field strength on that surface. (See Section 15.9.)

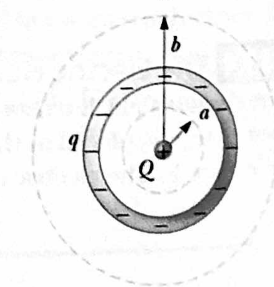


Figure WU15.14

CONCEPTUAL QUESTIONS

ENHANCED WebAssign The conceptual questions in this chapter may be assigned online in Enhanced WebAssign.

1. A glass object receives a positive charge of +3 nC by rubbing it with a silk cloth. In the rubbing process, have protons been added to the object or have electrons been removed from it?

2. Explain from an atomic viewpoint why charge is usually transferred by electrons.

3. A person is placed in a large, hollow metallic sphere that is insulated from ground. If a large charge is placed on the sphere, will the person be harmed upon touching the inside of the sphere?

4. Why must hospital personnel wear special conducting shoes while working around oxygen in an operating

15. **W** Two small metallic spheres, each of mass $m = 0.20$ g, are suspended as pendulums by light strings from a common point as shown in Figure P15.15. The spheres are given the same electric charge, and it is found that they come to equilibrium when each string is at an angle of $\theta = 5.0°$ with the vertical. If each string has length $L = 30.0$ cm, what is the magnitude of the charge on each sphere?

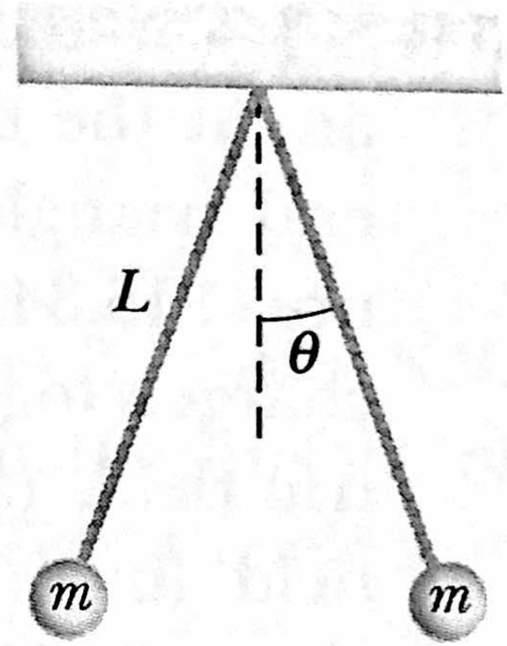


Figure P15.15