Name ____________________ Class ____________ Date ____________

Concept-Development Practice Page 9-1

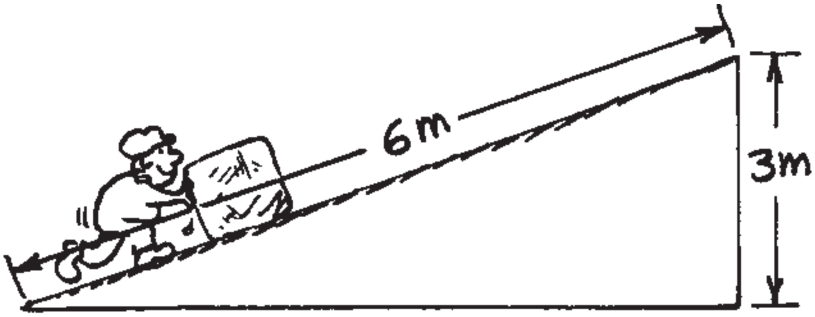
Work and Energy

1. How much work (energy) is needed to lift an object that weighs 200 N to a height of 4 m?
   800 J

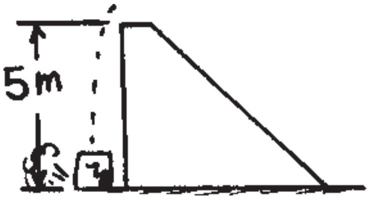
2. How much power is needed to lift the 200-N object to a height of 4 m in 4 s?
   200 W

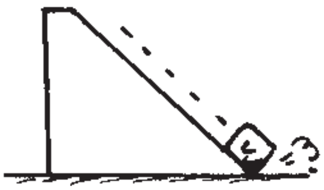
3. What is the power output of an engine that does 60,000 J of work in 10 s?
   6 kW

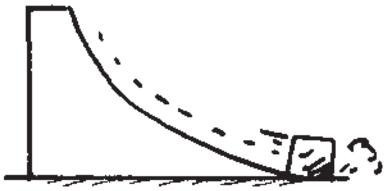
4. The block of ice weighs 500 newtons.
   a. What is the mechanical advantage of the incline?
      2:1
   b. How much force is needed to push it up the incline (neglect friction)?
      250 N



5. All the ramps are 5 m high. We know that the KE of the block at the bottom of the ramp will be equal to the loss of PE (conservation of energy). Find the speed of the block at ground level in each case. [*Hint*: Do you recall from earlier chapters how long it takes something to fall a vertical distance of 5 m from a position of rest (assume $g = 10\ \text{m/s}^2$)? And how much speed a falling object acquires in this time? This gives you the answer to Case 1. Discuss with your classmates how energy conservation gives you the answers to Cases 2 and 3.]



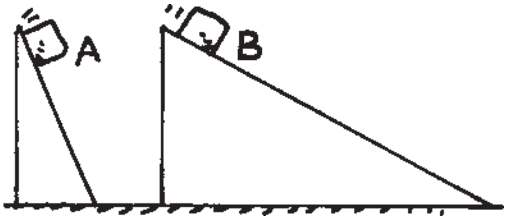




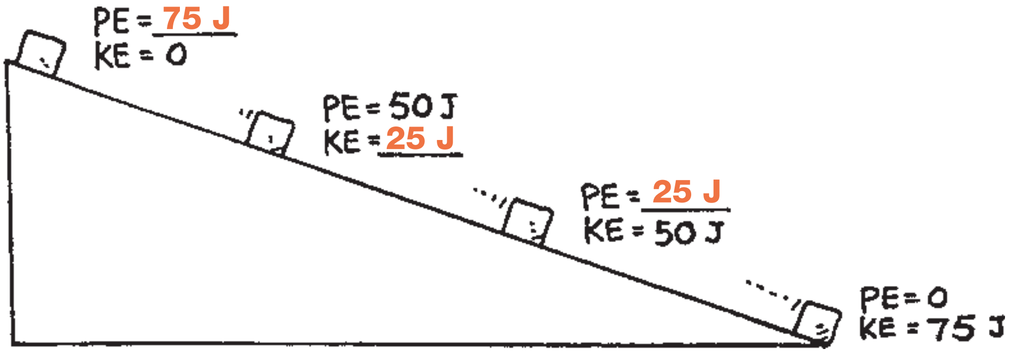
Case 1: Speed = 10 m/s Case 2: Speed = 10 m/s Case 3: Speed = 10 m/s

Block on A reaches bottom first; greater acceleration and less ramp distance. Although it will have the same *speed* at bottom, the *time* it takes to reach that speed is different!

6. Which block gets to the bottom of the incline first? Assume no friction. (Be careful!) Explain your answer.
Ball A gets to the bottom first due to a greater acceleration down a shorter ramp. (Note that SPEED at the bottom, not TIME, is the same for both.)



7. The KE and PE of a block freely sliding down a ramp are shown in only one place in the sketch. Fill in the missing values.



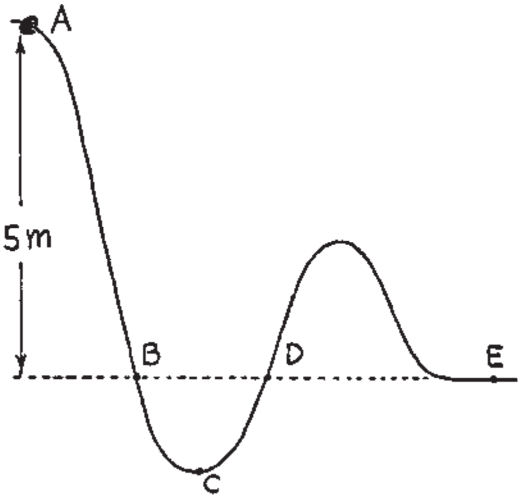
8. A big metal bead slides due to gravity along an upright friction-free wire. It starts from rest at the top of the wire as shown in the sketch. How fast is it traveling as it passes

Point B? 10 m/s

Point D? 10 m/s

Point E? 10 m/s

At what point does it have the maximum speed? C

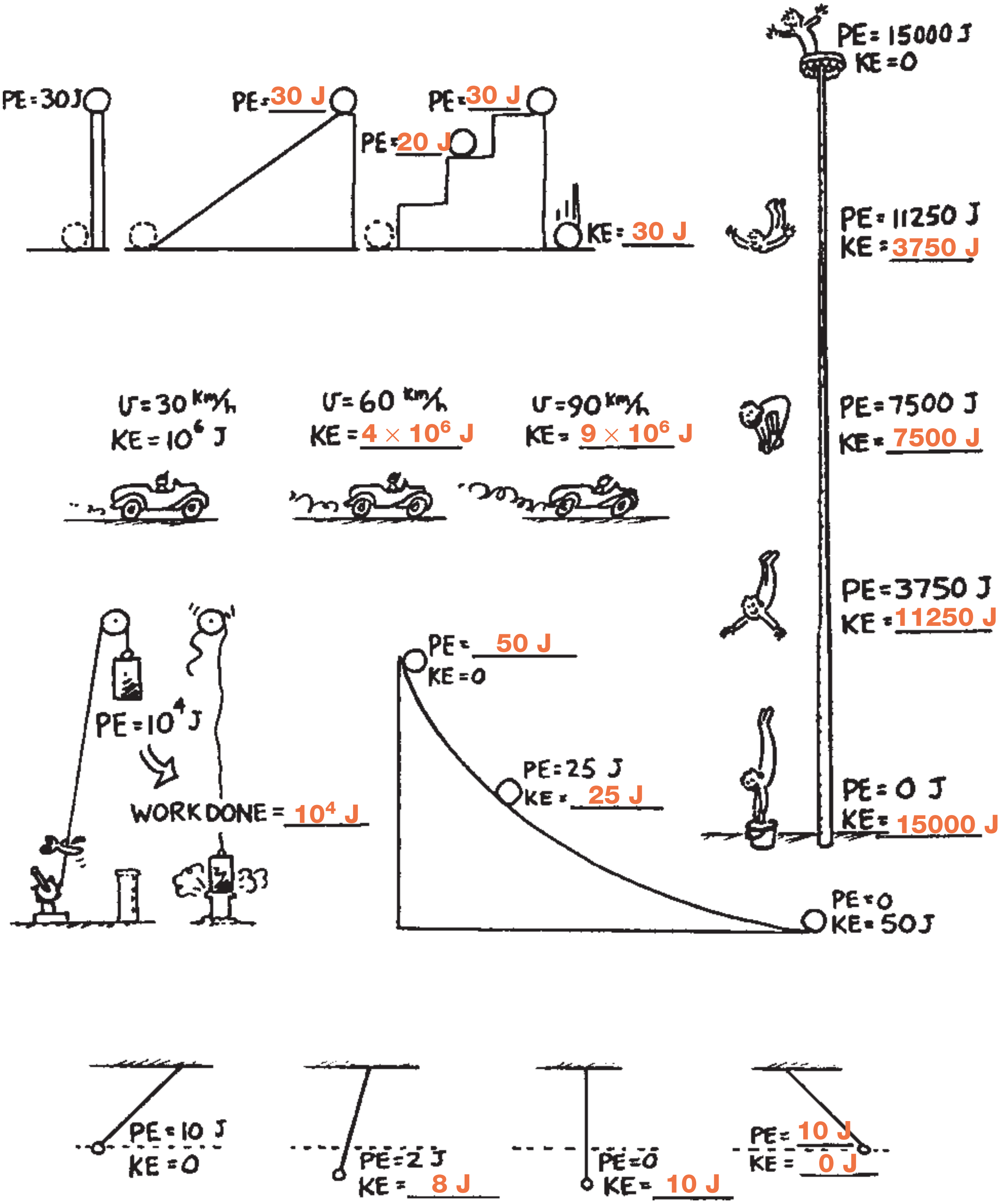


9. Rows of wind-powered generators are used in various windy locations to generate electric power. Does the power generated affect the speed of the wind? Would locations behind the "windmills" be windier if they weren't there? Discuss this in terms of energy conservation with your classmates.
Yes, by the conservation of energy, the energy gained by the windmills is taken from the KE of the wind. So strictly speaking, the wind must slow down and locations behind would be a bit windier without the windmills.

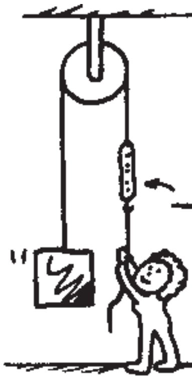
Concept-Development Practice Page 9-2

Conservation of Energy

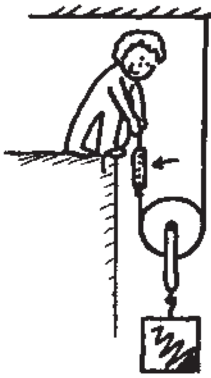
1. Fill in the blanks for the six systems shown.



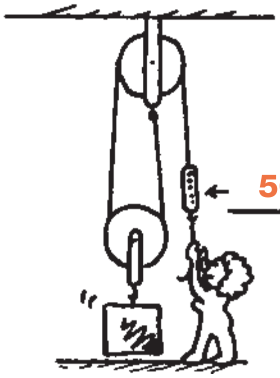
2. The woman supports a 100-N load with the friction-free pulley systems shown below. Fill in the spring-scale readings that show how much force she must exert.



100 N

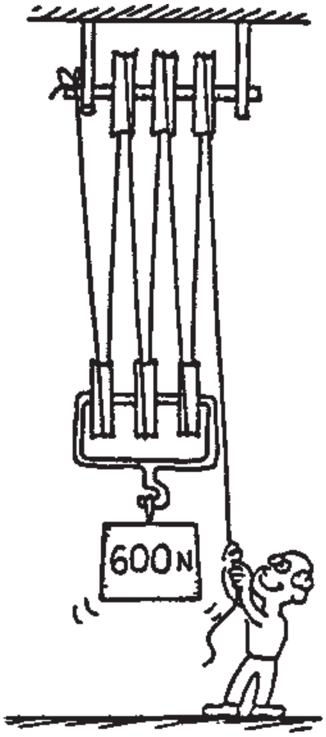


50 N



50 N

3. A 600-N block is lifted by the friction-free pulley system shown.



a. How many strands of rope support the 600-N weight?

6

b. What is the tension in each strand?

100 N

c. What is the tension in the end held by the man?

100 N

d. If the man pulls his end down 60 cm, how many cm will the weight rise?

10 cm

e. What is the ideal mechanical advantage of the pulley system?

6:1

f. If the man exerts 60 joules of work, what will be the increase of PE of the 600-N weight?

The same, 60 J

4. Why don't balls bounce as high during the second bounce as they do in the first?

During each bounce, some of the ball's mechanical energy is transformed into heat (and even sound), so the PE decreases with each bounce.

Exercises

9.1 Work (pages 145–146)

1. Circle the letter next to the correct mathematical equation for work.

a. work = force ÷ distance
b. work = distance ÷ force
[✓ c.] work = force × distance
d. work = force × $distance^2$

2. You can use the equation in Question 1 to calculate work when the force is constant and the motion takes place in a straight line in the direction of the force.

3. You do work if you lift a book one meter above the ground. How does the amount of work change in each of the following cases?

a. You lift the book twice as high. You do twice as much work.
b. You lift two identical books one meter above the ground. You do twice as much work.

4. Complete the table by naming the two general categories of work and giving an example of each.

Category of Work	Example
work done against another force	Possible answer: When an archer stretches her bow, she is doing work against the elastic forces of the bow.
work done to change the speed of an object	Possible answer: An engine does work increasing or decreasing the speed of a car.

5. The unit of work is the joule.

6. Suppose that you apply a 50-N horizontal force to a 25-kg box, pushing the box 6 meters across the floor. How much work do you do on the box? 300 J

9.2 Power (pages 146–147)

7. Power is the rate at which work is done.

8. Power equals work done divided by time interval.

9. The unit of power is the watt.

10. One megawatt (MW) equals one million watts.

11. In the United States, we customarily rate engines in units of horsepower, which is equivalent to 0.75 kilowatt.

9.3 Mechanical Energy (page 147)

12. Define energy.
the property of an object or system that enables it to do work

13. What is the SI unit of energy? joule

14. Mechanical energy is the energy due to the position or movement of something.

15. What are the two forms of mechanical energy?

a. kinetic energy

b. potential energy

9.4 Potential Energy (pages 148–149)

16. On each line, write *elastic*, *chemical*, or *gravitational* to identify the type of potential energy described.

chemical a. fossil fuels

elastic b. a compressed spring

gravitational c. water in a reservoir

elastic d. a stretched rubber band

chemical e. food

elastic f. a bow drawn back

chemical g. electric batteries

17. The amount of gravitational potential energy possessed by an elevated object is equal to the work done against gravity in lifting it.

18. What are two ways to calculate gravitational potential energy?

a. weight × height

b. mass × acceleration due to gravity (g) × height

19. Explain what the height is when you calculate an object's gravitational potential energy.

The height is the distance above some chosen reference level, such as the ground or the floor of a building.

20. How do hydroelectric power stations make use of gravitational potential energy?

Water from an upper reservoir flows through a long tunnel to an electric generator. Here, gravitational potential energy of the water is converted to electrical energy.

9.5 Kinetic Energy (page 150)

21. Kinetic energy is energy of motion.

22. Circle the letter for the equation you can use to find the kinetic energy of an object.

a. KE = $2mv$

b. KE = $\frac{1}{2}mv$

c. KE = $2mv^2$

[✓ d.] KE = $\frac{1}{2}mv^2$

23. Kinetic energy equals the net force on an object multiplied by the distance the object moves.

24. Is the following sentence true or false? If the speed of an object doubles, the kinetic energy of the object also doubles. false

9.6 Work-Energy Theorem (pages 151–152)

25. Express the work-energy theorem.

Whenever work is done, energy changes.

26. Explain this equation: Work = ΔKE.

Work equals change in kinetic energy.

27. Is the following sentence true or false? If you push against a heavy refrigerator, and it doesn't slide, then you are not doing work on the refrigerator.

true

28. Suppose you push against a box so that it moves across a horizontal surface. Explain how to determine the change in kinetic energy in each of the following cases.

a. The surface has no friction. ΔKE equals your push times the distance of your push.

b. The surface has some friction. ΔKE equals the net force, which is your push minus the frictional force, multiplied by the distance of your push.

c. The box moves at a constant speed across a surface that has some friction.
The net force and net work are zero, and the kinetic energy doesn't change.

29. Is the following sentence true or false? The maximum friction that the brakes of a car can supply is nearly the same whether the car moves slowly or quickly.

true

Match each form of hidden kinetic energy with its description.

	Form of Kinetic Energy	**Description**
c	**30.** heat	a. consists of molecules vibrating in rhythmic patterns
a	**31.** sound	b. produced by electrons in motion
b	**32.** electricity	c. results from random molecular motion

9.7 Conservation of Energy (pages 153–154)

33. The energy an arrow delivers to a target is slightly less than the energy it had when it was flying toward the target. What happened to the lost energy?

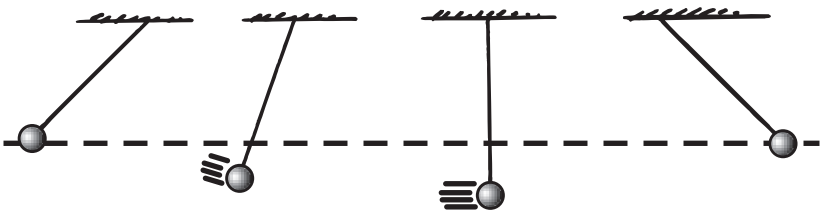
It was transformed into heat that warmed the arrow and target.

34. Express the law of conservation of energy.

Energy cannot be created or destroyed. It can be transformed from one form into another, but the total amount of energy never changes.

35. The wound spring of a toy car has 10 J of potential energy. Only 8 J of this energy changes to kinetic energy as the car moves. What happens to the remaining 2 J of energy?

It changes to heat in the machinery due to friction.



36. The figure above shows the energy of a swinging pendulum bob at different points along its path.

a. If you ignore friction, how does the energy of the bob at the highest points of its path compare to the energy at the lowest point of its path?

The energy is all potential energy at the highest points and all kinetic energy when the bob is at the lowest point.

b. How does friction affect the pendulum?

Friction gradually changes the energy to heat, and the pendulum eventually stops.

37. The sun shines because some of its nuclear energy is transformed into radiant energy.

38. In nuclear reactors, nuclear energy is transformed into heat.

39. Suppose a person in distress leaps from a burning building onto a firefighter's trampoline near the ground.

a. Describe the change in potential energy, kinetic energy, and total energy as the person falls.

The potential energy changes to kinetic energy. The total energy doesn't change.

b. Suppose the person has 10,000 J of potential energy just before jumping. What are the person's potential energy and kinetic energy upon reaching the trampoline?

The potential energy is zero. The kinetic energy is 10,000 J.

9.8 Machines (pages 155–157)

40. A machine is a device used to multiply forces or change the direction of forces.

41. Circle each letter that describes something a machine can do.

a. puts out more energy than is put into it

[✓ b.] transfers energy from one place to another

[✓ c.] transforms energy from one form to another

d. destroys or creates energy

42. Describe a lever.

a simple machine made of a bar that turns about a fixed point

43. Complete the following mathematical equation for a lever.

$$(\text{force} \times \text{distance})_{\text{input}} =$$
$$(\text{force} \times \text{distance})_{\text{output}}$$

44. The pivot point of a lever is called a fulcrum.

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Gravitational Potential Energy

Calculate the increase in potential energy when a crane lifts a 2,000-kg car a vertical distance of 10 m. The acceleration due to gravity (*g*) is 10 m/s^2.

1. Read and Understand

What information are you given?

Mass of the car, $m = 2{,}000$ kg

Height of the car, $h = 10$ m

2. Plan and Solve

What unknown are you trying to calculate?

Gravitational potential energy = PE

What mathematical equation can you use to calculate the unknown?

Gravitational potential energy, PE = mgh

Substitute the information you know into the equation.

$$\text{PE} = mgh$$
$$= (2{,}000 \text{ kg})(10 \text{ m/s}^2)(10 \text{ m})$$

Multiply to find the unknown.

PE = 200,000 J = 200 kJ

3. Look Back and Check

Is your answer reasonable?

The magnitude of the potential energy is 100 times the mass of the car. This is reasonable because the car is lifted 10 m.

Math Practice

On a separate sheet of paper, solve the following problems.

1. A football player throws a ball with a mass of 0.34 kg. What is the gravitational potential energy of the ball when it is 5.0 m above the ground?
   PE = mgh = (0.34 kg)(10 m/s^2)(5.0 m) = 17 J

2. A 2.0-kg book is on a shelf that is 1.6 m high. What is the gravitational potential energy of the book relative to the ground?
   PE = mgh = (2.0 kg)(10 m/s^2)(1.6 m) = 32 J

3. A 36-kg girl walks to the top of stairs that are 2.0-m high. How much gravitational potential energy does the girl gain?
   PE = mgh = (36 kg)(10 m/s^2)(2.0 m) = 720 J

4. A can of soup has a mass of 0.35 kg. The can is moved from a shelf that is 1.2 m off the ground to a shelf that is 0.40 m off the ground. How does the gravitational potential energy of the can change?
   ΔPE = mgh = (0.35 kg)(10 m/s^2)(0.40 m – 1.2 m) = –2.8 J

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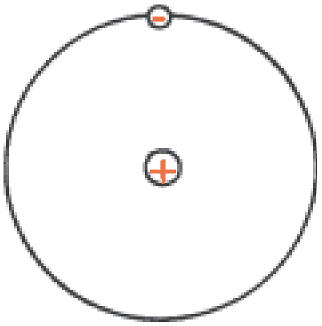
Concept-Development Practice Page 32-1

Coulomb's Law

1. The diagram is of a hydrogen atom.

   a. Label the proton in the nucleus with a + sign and the orbital electron with a – sign.



   b. The electrical interaction between the nucleus and the orbital electron is a force of

   [✓ (attraction)] (repulsion).

   c. According to Coulomb's law,

$$F = k\frac{q_1 q_2}{d^2}$$

   if the charge of either the nucleus or the orbital electron were greater, the force between the nucleus and the electron would be

   [✓ (greater)] (less)

   and if the distance between the nucleus and electron were greater the force would be

   (greater) [✓ (less)].

   If the distance between the nucleus and electron were doubled, the force would be

   [✓ (1/4 as much)] (1/2 as much) (two times as much) (4 times as much).

2. Consider the electric force between a pair of charged particles a certain distance apart. By Coulomb's law:

   a. If the charge on one of the particles is doubled, the force is

   (unchanged) (halved) [✓ (doubled)] (quadrupled).

   b. If instead the charge on both particles is doubled, the force is

   (unchanged) (halved) (doubled) [✓ (quadrupled)].

   c. If instead the distance between the particles is halved, the force is

   (unchanged) (halved) (doubled) [✓ (quadrupled)].

   d. If the distance is halved, *and* the charge of both particles is doubled, the force is ____16____ times as great.

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Concept-Development Practice Page 32-2

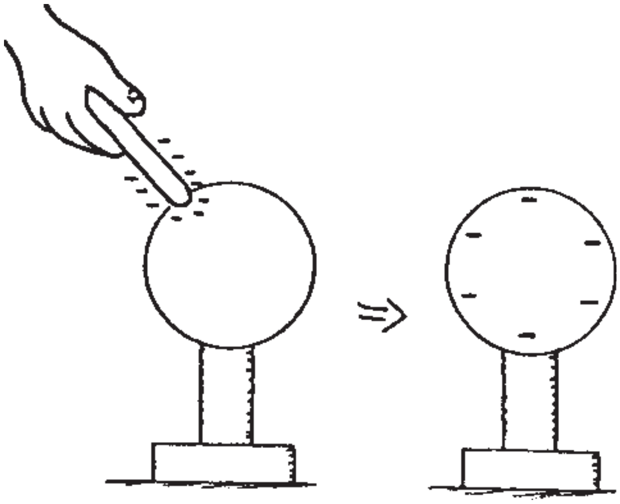
Electrostatics

1. The outer electrons in metals are not tightly bound to the atomic nuclei. They are free to roam in the material. Such materials are good

   [✓ (conductors)] (insulators).

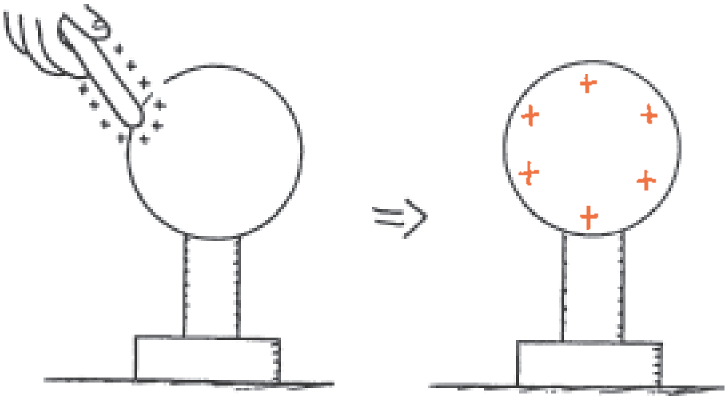
   Electrons in other materials are tightly bound to the atomic nuclei, and are not free to roam in the material. These materials are good

   (conductors) [✓ (insulators)].



2. A rubber rod that has been rubbed with fur is negatively charged because rubber holds electrons better than fur does. When the rod touches a metal sphere, some of the charge from the rod spreads onto the metal sphere because like charges repel one another. When the rod is removed the charge spreads evenly over the metal sphere and remains there because the insulating stand prevents its flow to the ground. The negatively charged rod has given the sphere a negative charge. This is *charging by contact,* and is shown to the right.

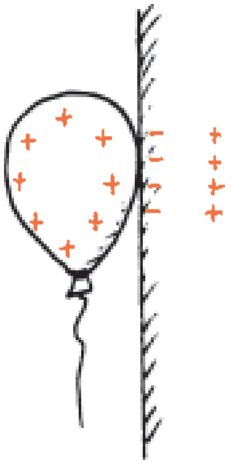
   Label the right-hand sphere below with the appropriate charges below for a positively-charged rod touching a metal sphere.



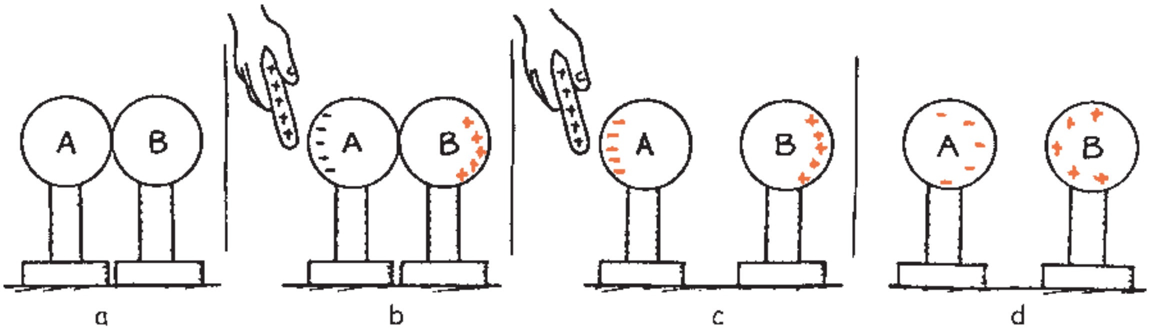
3. In the examples above, electric charge is

   (created from nothing) [✓ (simply transferred from one body to another)].

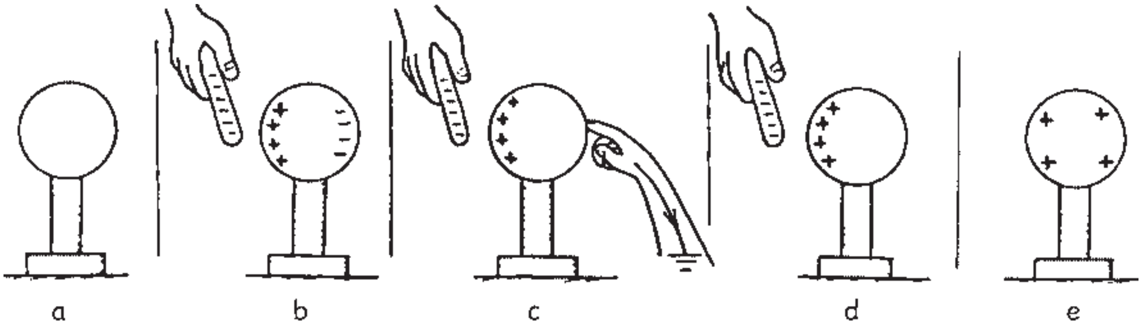
4. A positively-charged balloon will stick to a wooden wall. It does this by polarizing molecules in the wooden wall to create an oppositely-charged surface. Draw the appropriate charges on both the balloon and in the wall. Your completed diagram should be similar to Figure 32.13 in your textbook.



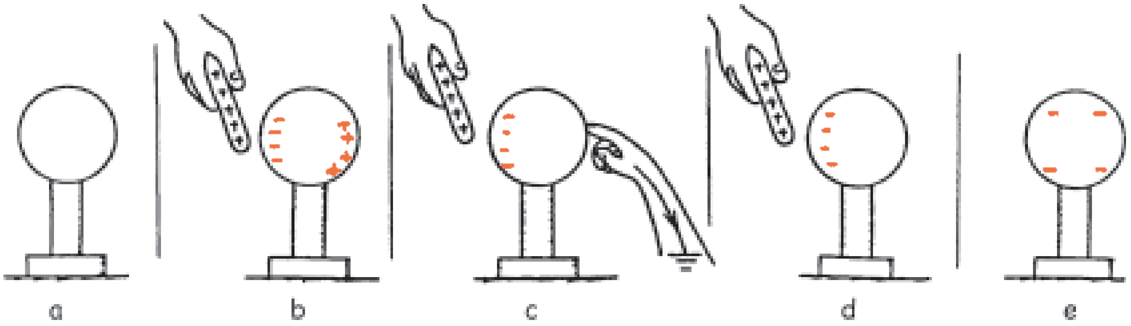
5. Consider the diagrams below. (a) A pair of insulated metal spheres, A and B, touch each other, so in effect they form a single uncharged conductor. (b) A positively charged rod is brought near A, but not touching, and electrons in the metal sphere are attracted toward the rod. Charges in the spheres have redistributed, and the negative charge is labeled. Draw the appropriate + signs that are repelled to the far side of B. Draw the signs of charge in (c), when the spheres are separated while the rod is still present, and in (d) after the rod has been removed. Your completed work should be similar to Figure 32.8 in the textbook. The spheres have been charged by *induction*.



6. Consider below a single metal insulated sphere, (a), initially uncharged. When a negatively charged rod is nearby, (b), charges in the metal are separated. Electrons are repelled to the far side. When the sphere is touched with your finger, (c), electrons flow out to the sphere to Earth through the hand. The sphere is "grounded." Note the positive charge left (d) while the rod is still present and your finger removed, and (e) when the rod is removed. This is an example of *charge induction by grounding*. In this procedure the negative rod "gives" a positive charge to the sphere.



The diagrams below show a similar procedure with a positive rod. Draw the correct charges in the diagrams.



Exercises

32.1 Electrical Forces and Charges (pages 645–646)

1. Circle the letter beside the correct comparison of the strengths of the gravitational force and the electrical force.
   - a. The gravitational force is slightly stronger than the electrical force.
   - b. The electrical force is slightly stronger than the gravitational force.
   - c. The gravitational force is much stronger than the electrical force.
   - [✓ d.] The electrical force is much stronger than the gravitational force.
2. Why don't you feel the electrical forces that act on you all the time?
   Both repelling and attracting forces act on you, and the forces cancel each other out.
3. Describe the simple model of the atom proposed in the early 1900s by Rutherford and Bohr.
   The atom has a positively charged nucleus surrounded by electrons. The protons attract and hold the electrons in orbit.
4. Charge is the fundamental electrical property to which the mutual attractions or repulsions between electrons or protons is attributed.
5. By convention, what is the charge of the following?
   - a. electrons negative
   - b. protons positive
   - c. neutrons no charge
6. Is the following sentence true or false? The mass of a proton is 2000 times greater than the mass of an electron. true
7. Circle the letter beside the correct comparison of the *magnitudes* of the charges of a proton and an electron.
   - a. The magnitude of the proton's charge is slightly greater.
   - b. The magnitude of the electron's charge is slightly greater.
   - c. The magnitudes of a proton's charge and an electron's charge are always equal, but they vary for different atoms.
   - [✓ d.] The magnitudes of a proton's charge and an electron's charge are always equal and never change.
8. Like charges repel and opposite charges attract.

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32.2 Conservation of Charge (pages 646–647)

9. Explain why there is no net charge in a neutral atom.
There are as many electrons as protons. The positive and negative charges balance.

10. A charged atom is called a(n) ion.

11. The ______________ of many atoms are bound very loosely to an atom and can be easily dislodged. Circle the correct answer.

[✓ a. outermost electrons]
b. innermost electrons
c. outermost protons
d. innermost protons

12. If a rubber rod is rubbed by a piece of fur, the rubber becomes negatively charged and the fur becomes positively charged.

13. What is the principle of conservation of charge?
Electrons are neither created nor destroyed but are simply transferred from one material to another.

32.3 Coulomb's Law (pages 648–650)

14. What does Coulomb's law state?
For charged particles or objects that are small compared with the distance between them, the force between the charges varies directly as the product of the charges and inversely as the square of the distance between them.

Match each variable or constant in Newton's law of gravitation with its analogous variable or constant in Coulomb's law.

c	**15.** m_1	a. d
d	**16.** m_2	b. k
a	**17.** d	c. q_1
b	**18.** G	d. q_2

19. The SI unit of charge is the coulomb.

20. How many electrons are contained in 1 C of charge?
6.24×10^{18}

21. Is the following sentence true or false? The electrical force between two protons is very small compared to the gravitational force. false

32.4 Conductors and Insulators (pages 651–652)

22. A material through which electric charge can flow is a(n) electric conductor.

23. A material that is a poor conductor of electricity is a(n) electric insulator.

24. Define semiconductor.
material that can be made to behave sometimes as insulators and sometimes as conductors

25. Classify the following by writing *C* beside each conductor, *I* beside each insulator, and *S* beside each semiconductor.

C a. aluminum
C b. copper
S c. germanium
I d. glass
I e. rubber
S f. silicon

26. What effect will adding an impurity level of one atom in ten million to a crystal of semiconductor have?
The impurity adds or removes an electron from the crystal structure, which increases conductivity.

27. Is the following sentence true or false? Atoms in a semiconductor hold their electrons until the atoms of the semiconductor are given small energy boosts. true

28. Thin layers of semiconducting materials sandwiched together make up transistors, which are used in a variety of electrical applications.

32.5 Charging by Friction and Contact (page 652)

29. Classify each of the following by writing *F* if it is an example of charging an object by friction and *C* if it is an example of charging an object by contact.

F a. sliding across the seat of an automobile
F b. scuffing your shoes as you walk across a rug
C c. touching a charged rod to a metal sphere
F d. combing your hair with a plastic comb
C e. touching your hand to a slightly charged metal plate

30. One object charges a second object by contact. Describe what will happen to the charge on the second object in each of the cases below.

a. The second object is a good conductor.
The charge will spread to all parts of the second object's surface.

b. The second object is a poor conductor.
The extra charge will stay close to where the second object was touched.

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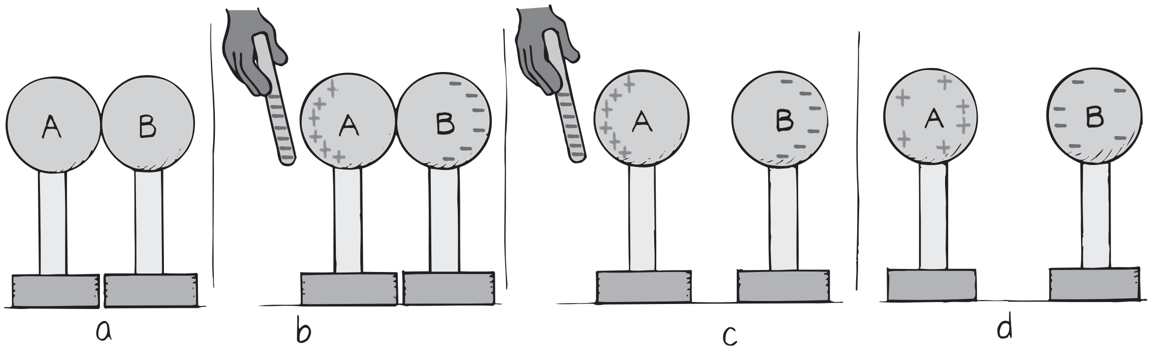
32.6 Charging by Induction (pages 653–654)

Use the figure below to answer Questions 31–33.



31. Why do the positive and negative charges separate in part (b)?

A negatively charged rod near sphere A repels electrons, and excess negative charge moves onto sphere B, leaving sphere A with excess positive charge.

32. Why do the positive and negative charges spread out on each on the spheres in part (d)?

The like charges repel each other on each of the spheres.

33. Why is the process illustrated in the figure an example of charging by induction?

A charged object charged each of the spheres without touching them.

34. The ______ground______ is a practically infinite reservoir for electric charge.

35. Circle each letter next to a discovery made by Benjamin Franklin.

a. electricity

[✓ b.] Lightning is an electrical phenomenon.

[✓ c.] lightning rods

d. Electricity can travel along metal wires.

36. Describe what causes lightning to occur during thunderstorms.

The negatively charged bottoms of clouds induce a positive charge on the surface of Earth below. Lightning can occur as an electrical discharge between the clouds and the oppositely charged ground below.

37. Is the following sentence true or false? A lightning rod placed above a building repels electrons in the air to prevent leaking of the charge onto the ground. ______false______

32.7 Charge Polarization (pages 655–657)

38. Describe an electrically polarized atom or molecule.

One side of the atom or molecule is slightly more positive (or negative) than the opposite side.

39. Why can an insulator become polarized when you bring a conducting rod near it?

There are no free electrons to migrate through the insulating material. Instead, there is a rearrangement of the positions of charges within the atoms and molecules.

40. Circle the letter beside the sentence that explains why a charged comb attracts an uncharged piece of paper.

a. The forces of attraction and repulsion on opposite sides of the paper cancel.

b. The forces of attraction and repulsion on the paper disappear with the comb nearby.

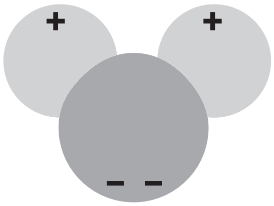
[✓ c.] The force of attraction for the closer charge is greater than the force of repulsion for the farther charge.

d. The force of repulsion for the closer charge is greater than the force of attraction for the farther charge.

41. Explain why the bits of paper sometimes suddenly fly off when a comb attracts bits of uncharged paper.

This indicates charging by contact. The paper bits have acquired the same sign of charge as the comb, and are then repelled.

42. When you rub an inflated balloon on your hair and it becomes negatively charged, the charge on the balloon induces a ____positive____ charge on the surface of the wall.



43. Why is the water molecule shown in the figure above an electric dipole?

It has a little more negative charge on one side than the other.

44. What are the three ways objects can become electrically charged?

a. ____friction____

b. ____contact____

c. ____induction____

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Coulomb's Law

Consider a pair of charged particles separated by a distance d. If the distance between the particles is multiplied by 4, how will the electrostatic force between the particles change?

1. Read and Understand

What information are you given?

Two charged particles, q_1 and q_2, are a distance d apart.

An electrostatic force, F, exists between the particles.

The final distance equals $4d$.

2. Plan and Solve

What unknown are you trying to calculate?

Electrostatic force after the distance changes, $F_{\text{new}} = ?$

What mathematical relationship can you use to find the unknown?

Coulomb's law: $F = k\dfrac{q_1q_2}{d^2}$

Apply this law to find the new force after the distance changes.

$$F_{\text{new}} = k\frac{q_1q_2}{(4d)^2} = k\frac{q_1q_2}{16d^2} = \left(\frac{1}{16}\right)F$$

3. Look Back and Check

Is your answer reasonable?

Yes, the distance increased by a factor of 4, so the force should decrease by a factor of 4 squared, or 16.

Math Practice

On a separate sheet of paper, solve the following problems. Consider a pair of particles separated by a distance d.

1. If the charge of each particle tripled and the distance also tripled, how would the electrostatic force between the particles change?

   $F_{\text{new}} = k\dfrac{(3q_1)(3q_2)}{(3d)^2} = F$; the force would not change.

2. If the charge of one particle doubled and the charge of the other particle tripled, how would the electrostatic force between the particles change?

   $F_{\text{new}} = k\dfrac{(2q_1)(3q_2)}{d^2} = 6F$; the force would increase by a factor of 6.

3. If the charge of one particle were reduced to one-half the original charge and the distance between the charges were multiplied by 2, how would the electrostatic force between the particles change?

   $F_{\text{new}} = k\dfrac{\left[\left(\frac{1}{2}\right)q_1\right](q_2)}{(2d)^2} = \left(\dfrac{1}{8}\right)F$; the force would be reduced by a factor of 8.

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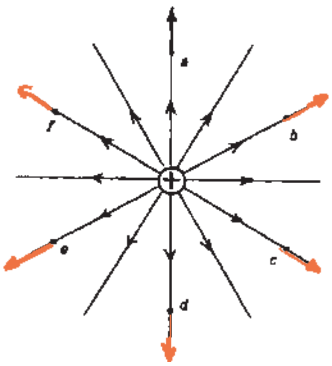
Concept-Development Practice Page 33-1

Electric Field

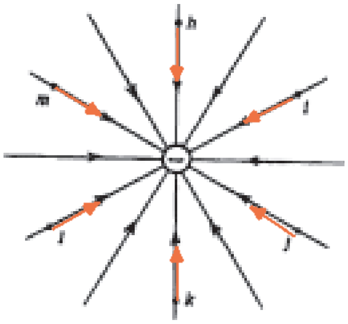


1. An *electric field* surrounds an electric charge. The field strength at any place in the field can be found by placing a small positive test charge there. Where the force on the test charge is great, the field strength is great; where the force is weak, the field strength is weak. Electric field strength is directly proportional to the force exerted on a positive test charge.

   The direction of an electric field at any point is the same as the direction of the force exerted on the positive test charge.

   Some electric field lines surrounding a positive charge are shown above. They extend radially from the charge. A vector is sketched at point *a* to represent the force that would be exerted on a positive test charge there (its direction shows that like charges repel). Other points *b, c, d, e* and *f*, are all located at the same distance from the positive charge.

   Draw a vector at each of the points *b* – *f* to show the force on the same test charge.

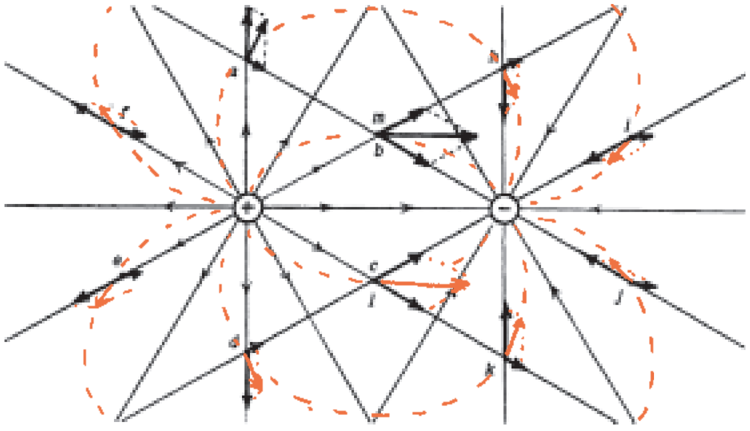


2. The electric field about a negative charge is shown to the right. The field lines point radially inward, in the same direction a positive test charge would be forced. Assume the magnitude of the negative charge is the same as the charge above.

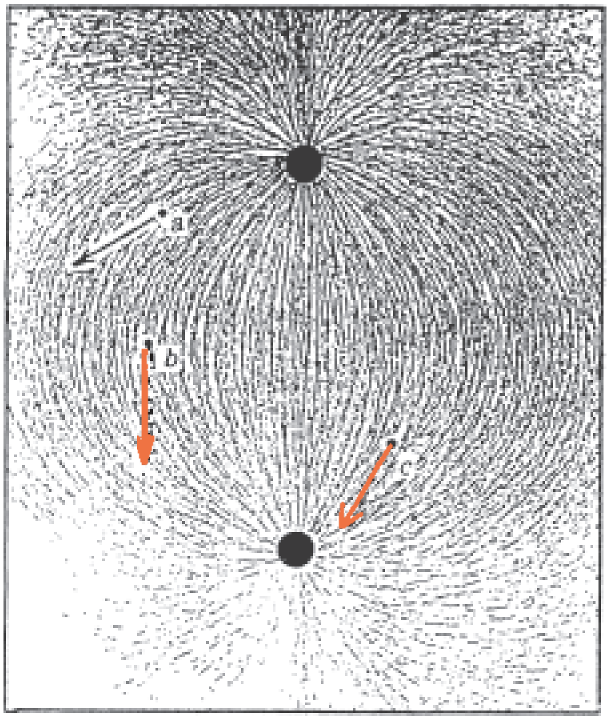
   Draw field vectors at each of the points *h* – *m*.

3. The pair of equal and opposite charges of Questions 1 and 2 is shown below. Their individual fields, drawn uninfluenced by each other, overlap to form a field pattern that can be constructed by vector rules. This is shown at locations *a* and *b*, where the two forces combine to a single resultant force. Note that point *b* overlaps point *m*, and also points *c* and *l* overlap. Note how the size of each vector depends on its distance from the charge (inverse-square law). Every point in the field is the result of both the positive and the negative charges.

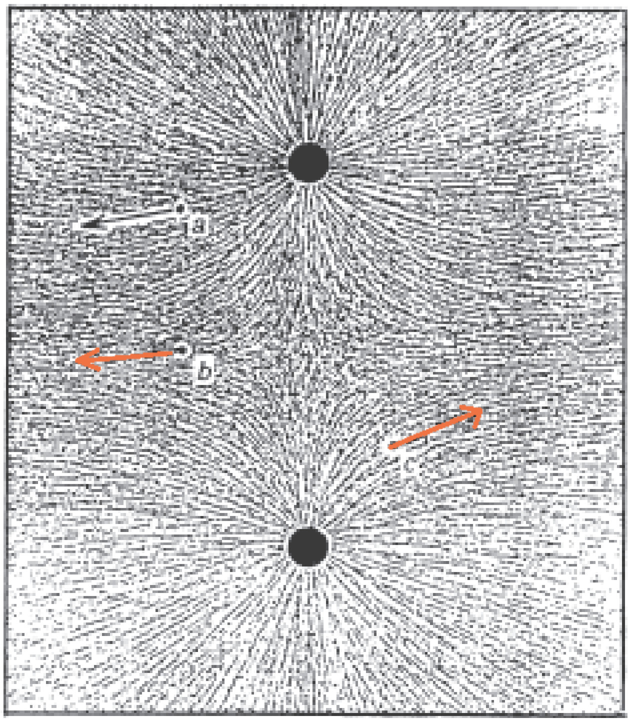
   By vector rules, show the resultant of all the vector pairs shown. Then sketch in sample vector resultants at a few other places. Does the pattern that emerges agree with the field patterns shown in Figure a on the next page? Yes



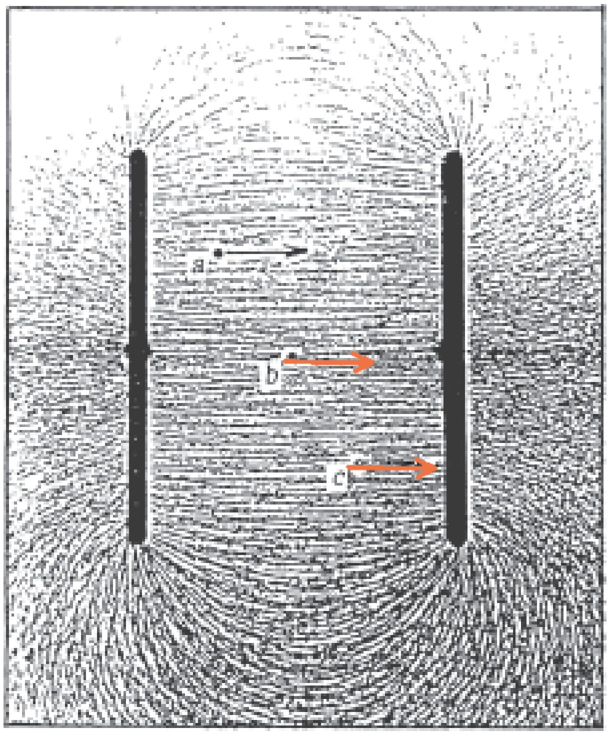
4. A copy of Figure 33.5 in your textbook is shown below. Three points, (*a, b, c*), are indicated on each electric field pattern. Point *a* in each pattern shows the electric field vector at that point. The vector indicates the magnitude and direction of the force that a positive test charge would experience at that point. (A curved field indicates that the force on a nearby test charge would be different in magnitude and direction.) Use the vector at points *a* as a reference and sketch in the electric field vectors for points *b* and *c* in each pattern, using colored ink or pencil.



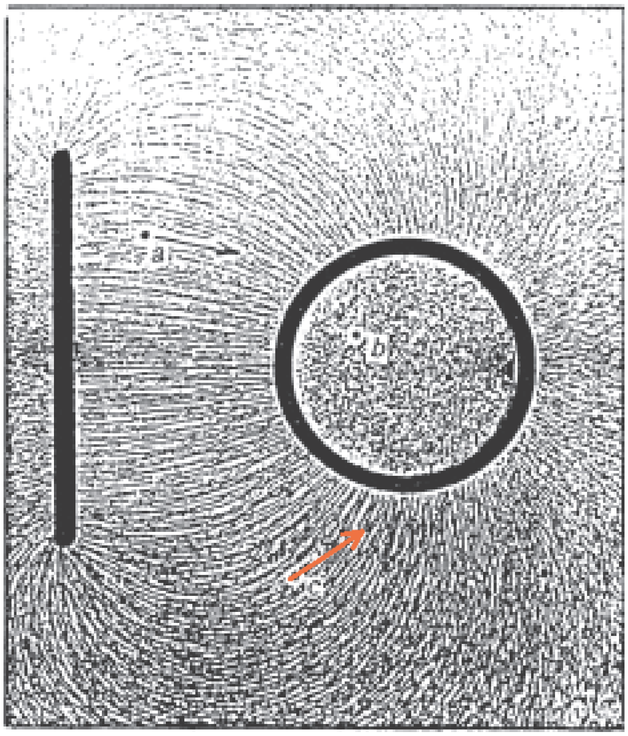
a. Equal and opposite charges



b. Equal like charges



c. Oppositely charged plates



d. Oppositely charged plate and cylinder

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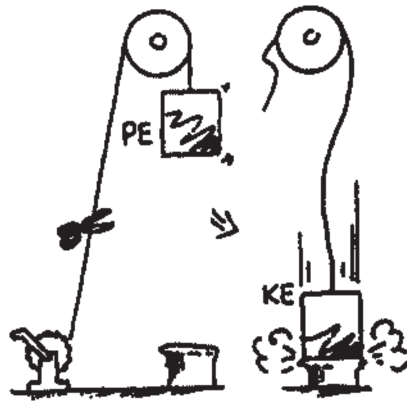
Concept-Development Practice Page 33-2

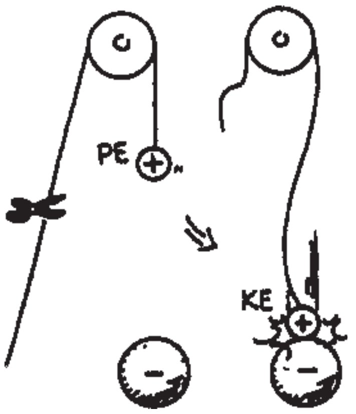
Electric Potential

1.



Just as PE (potential energy) transforms to KE (kinetic energy) for a mass lifted against the gravitational field (left), the electric PE of an electric charge transforms to other forms of energy when it changes location in an electric field (right). When released, how does the KE acquired by each compare to the decrease in PE?

KE = decrease in PE



2. *Complete the statements.*

A force compresses the spring. The work done in compression is the product of the average force and the distance moved. $W = Fd$. This work increases the PE of the spring.

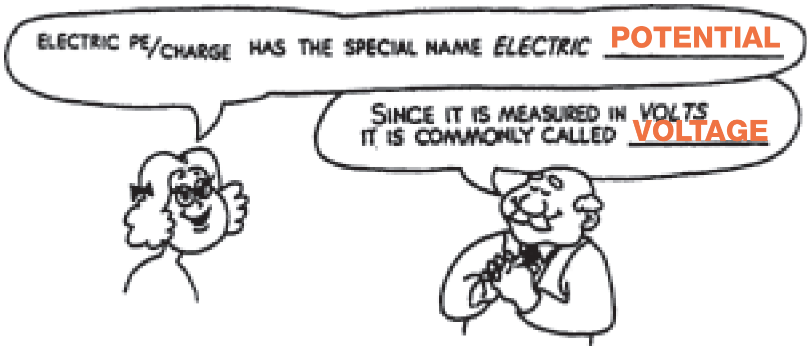
Similarly, a force pushes the charge (call it a test charge) closer to the charged sphere. The work done in moving the test charge is the product of the average force and the distance moved. $W =$ Fd. This work increases the PE of the test charge.

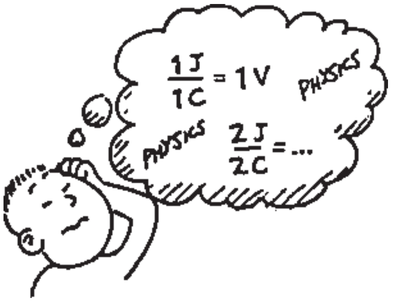
If the test charge is released, it will be repelled and fly past the starting point. Its gain in KE at this point is equal to its decrease in PE.

At any point, a greater quantity of test charge means a greater amount of PE, but not a greater amount of PE *per quantity* of charge. The quantities of PE (measured in joules) and PE/charge (measured in volts) are different concepts.

By definition: **Electric Potential = PE/charge.** 1 volt = 1 joule/1 coulomb

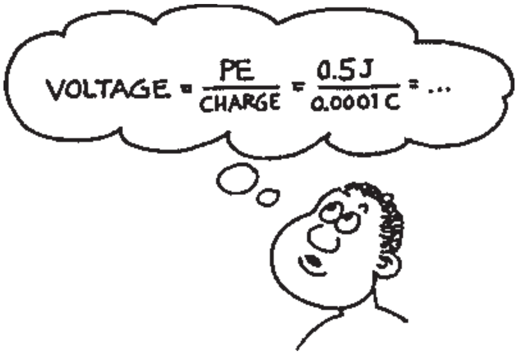
3. *Complete the statements.*





4. When a charge of 1 C has an electric PE of 1 J, it has an electric potential of 1 V. When a charge of 2 C has an electric PE of 2 J, its potential is 1 V.

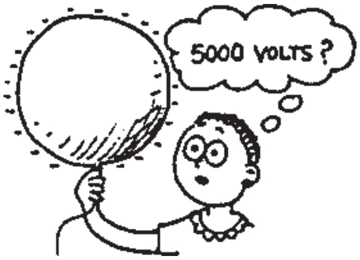
5. If a conductor connected to the terminal of a battery has a potential of 12 volts, then each coulomb of charge on the conductor has a PE of 12 J.



6. If a charge of 1 C has a PE of 5000 J, its voltage is 5000 V.

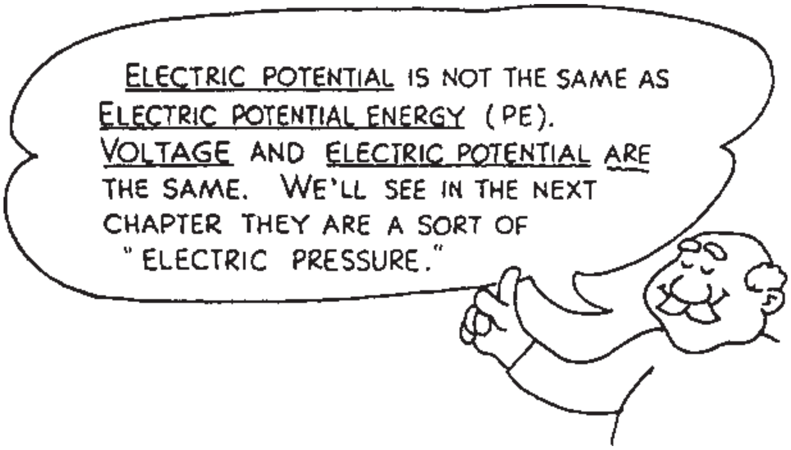
7. If a charge of 0.001 C has a PE of 5 J, its voltage is 5000 V.

8. If a charge of 0.0001 C has a PE of 0.5 J, its voltage is 5000 V.



9. If a rubber balloon is charged to 5000 V, and the quantity of charge on the balloon is 1 millionth coulomb, (0.000001 C) then the PE of this charge is only 0.005 J.

10. Some people get mixed up between force and pressure. Recall that pressure is force *per area.* Similarly, some people get mixed up between electric PE and voltage. According to this chapter, voltage is electric PE *per* charge.



Name ____________________ Class ______________ Date __________

Chapter 33 Electric Fields and Potential

Exercises

33.1 Electric Fields (pages 665–666)

1. What is an electric field?

a force field that surrounds an electric charge or group of charges

2. Like a gravitational field, an electric field has both magnitude and direction.

3. How can the magnitude of an electric field be measured?

The magnitude of an electric field can be measured by its effect on charges located in the field.

4. Is the following statement true or false? The direction of an electric field at any point, by convention, is the direction of the electrical force on a small *negative* test charge, placed at that point. false

5. Consider the electric field around a small positive charge. How can you describe the direction of the field?

The field points away from the charge.

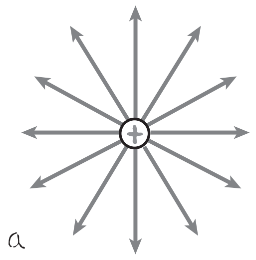
33.2 Electric Field Lines (pages 666–667)

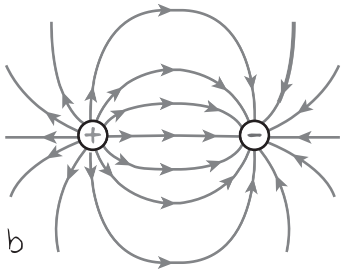
6. Since an electric field has both magnitude and direction, it is a vector quantity.

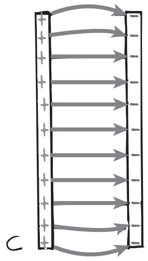
7. Is the following sentence true or false? In a vector representation of an electric field, the magnitude of an electric field is indicated by the length of the vector arrows. true

8. Electric fields can also be described by using field lines (or lines of force). In a field lines representation of an electric field, the field is weaker where the lines are farther apart.

Match the illustrations to the correct description.







9. b The field lines emanate from the positive charge and terminate on the negative charge.

10. c Field lines are evenly spaced between two oppositely charged plates.

11. a The field lines extend to infinity.

33.3 Electric Shielding (pages 668–669)

12. If the charge on a conductor is not moving, the electric field inside the conductor is exactly zero.

13. Circle the letter of each statement that is true about charged conductors.

a. The absence of an electric field within a conductor holding static charge arises from the inability of an electric field to penetrate metals.

[✓ b.] The absence of an electric field comes about because free electrons within the conductor stop moving when the electric field is zero.

[✓ c.] The charges arrange themselves to ensure a zero field within the material.

[✓ d.] If the conductor is not spherical, then the charge distribution will not be uniform.

14. Why are some electronic components and some cables encased in a metal covering?

They are encased in metal to shield them from all outside electrical activity.

33.4 Electrical Potential Energy (pages 669–670)

15. Is the following sentence true or false? A charged object has potential energy by virtue of its location in an electric field. true

16. Circle the letter of each statement that is true.

a. No work is required to push a charged particle against the electric field of a charged body.

b. The electrical potential energy of a charged particle decreases when work is done to push it against the electric field of something else that is charged.

[✓ c.] The energy a charge has due to its location in an electric field is called electrical potential energy.

[✓ d.] If a charge with electrical potential energy is released, its electrical potential energy will transform into kinetic energy.

33.5 Electric Potential (pages 670–671)

17. What is electric potential?

Electric potential is electrical potential energy per charge.

18. Is the following sentence true or false? Electric potential is *not* the same as electrical potential energy. true

19. The SI unit of measurement for electric potential is the volt.

20. Write an equation that expresses the relationship between volts, joules, and coulombs.

$1 \text{ volt} = \frac{1 \text{ joule}}{\text{coulomb}}$

21. What is voltage?

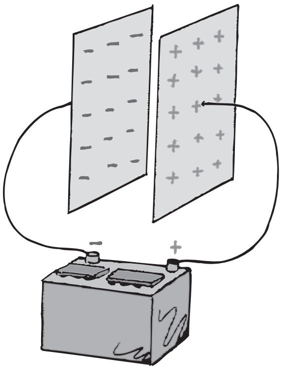
a measure of electric potential, expressed in volts

33.6 Electrical Energy Storage (pages 672–673)

22. What are two applications of capacitors?

Sample answer: Capacitors are used in computer memories, some computer keyboards, photoflashes, and giant lasers in national laboratories.

23. The diagram shows a simple capacitor. Explain how the capacitor is charged.



The positive battery terminal pulls electrons from the plate connected to it. These electrons are pumped through the battery and through the negative terminal to the opposite plate. The capacitor plates then have equal and opposite charges. The charging process is complete when the potential difference between the plates equals the potential difference between the battery terminals—the battery voltage.

24. A charged capacitor is discharged when a conducting path is provided between the plates.

25. The energy stored in a capacitor comes from the work done to charge it.

33.7 The Van de Graaff Generator (pages 673–674)

26. Is the following sentence true or false? In a Van de Graaff generator, as electrons leak off the belt and onto the conducting sphere, the electric field inside the sphere steadily increases in magnitude.

false

27. How can the voltage of a Van de Graaff generator be increased?

The voltage of a Van de Graaff generator can be increased by increasing the radius of the sphere or by placing the entire system in a container filled with high-pressure gas.

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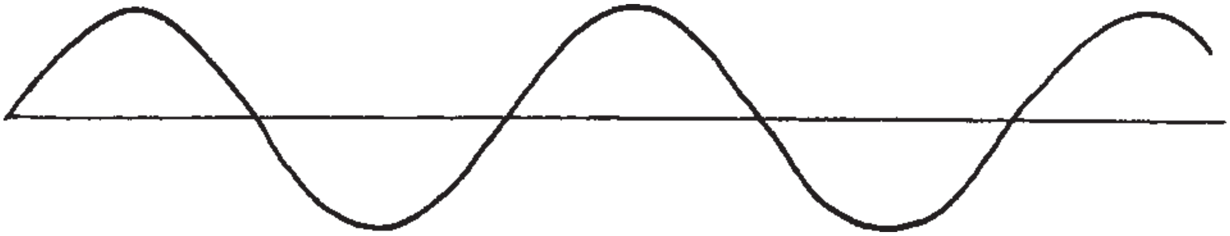
Concept-Development Practice Page 25-1

Vibrations and Waves

1. A sine curve that represents a transverse wave is drawn below. With a ruler, measure the wavelength and amplitude of the wave.



a. Wavelength = 7 cm

b. Amplitude = 1.5 cm

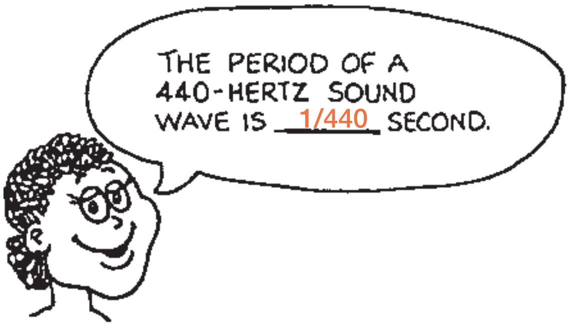
2. A kid on a playground swing makes a complete to-and-fro swing each 2 seconds. The frequency of swing is

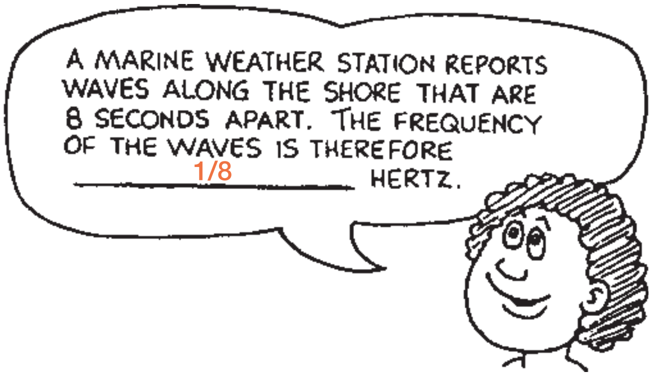
[✓ (0.5 hertz)] (1 hertz) (2 hertz)

and the period is

(0.5 second) (1 second) [✓ (2 seconds)].

3. *Complete the statements.*





4. The annoying sound from a mosquito is produced when it beats its wings at the average rate of 600 wingbeats per second.

a. What is the frequency of the soundwaves?

600 Hz

b. What is the wavelength? (Assume the speed of sound is 340 m/s.)

0.57 m

5. A pitching machine goes haywire and pitches at 10 rounds per second. The speed of the balls is an incredible 300 m/s.

   a. What is the distance in the air between the flying balls? 30 m

   b. What happens to the distance between the balls if the rate of pitching is increased?
   The distance between the balls decreases.

6. Consider a wave generator that produces 10 pulses per second. The speed of the waves is 300 cm/s.

   a. What is the wavelength of the waves? 30 cm

   b. What happens to the wavelength if the frequency of pulses is increased?
   The wavelength decreases, just as the distance between the balls in Question 5 decreases.

7. The bird at the right watches the waves. If the portion of a wave between two crests passes the pole each second, what is the speed of the wave?
   1 m/s

   What is its period?
   1 s

8. If the distance between crests in the above question was 1.5 meters, and two crests pass the pole each second, what would be the speed of the wave?
   1.5 m/s

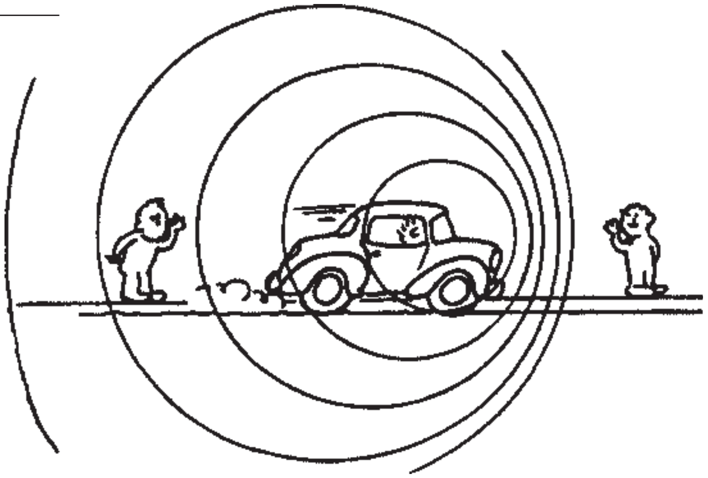
   What would be its period?
   1 s (the same)

9. When an automobile moves toward a listener, the sound of its horn seems relatively

   (low pitched) (normal)
   [✓ (high pitched)]

   and when moving away from the listener, its horn seems

   [✓ (low pitched)] (normal)
   (high pitched).



10. The changed pitch of the Doppler effect is due to changes in
   (wave speed) [✓ (wave frequency).]

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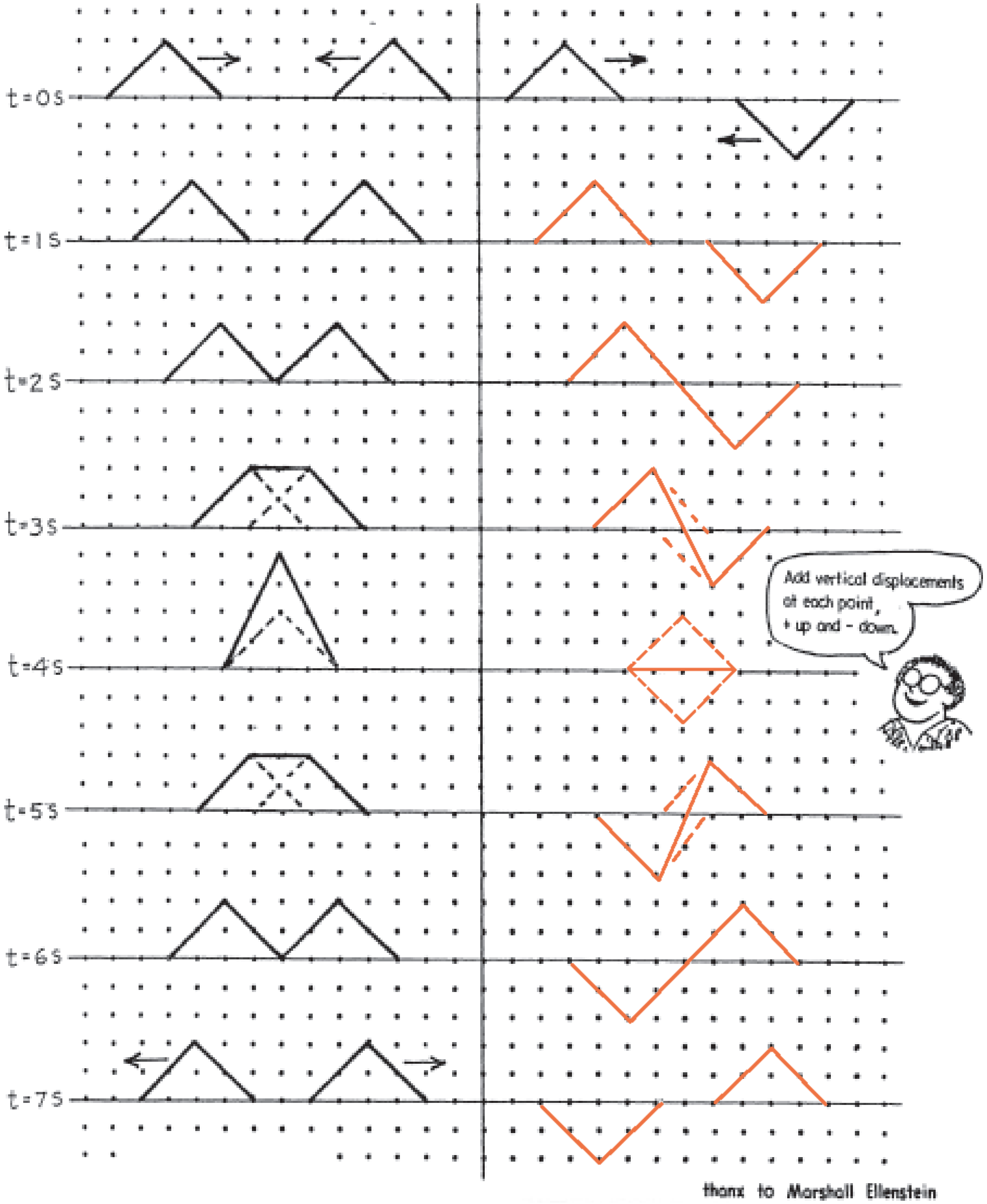
Concept-Development Practice Page 25-3

Wave Superposition

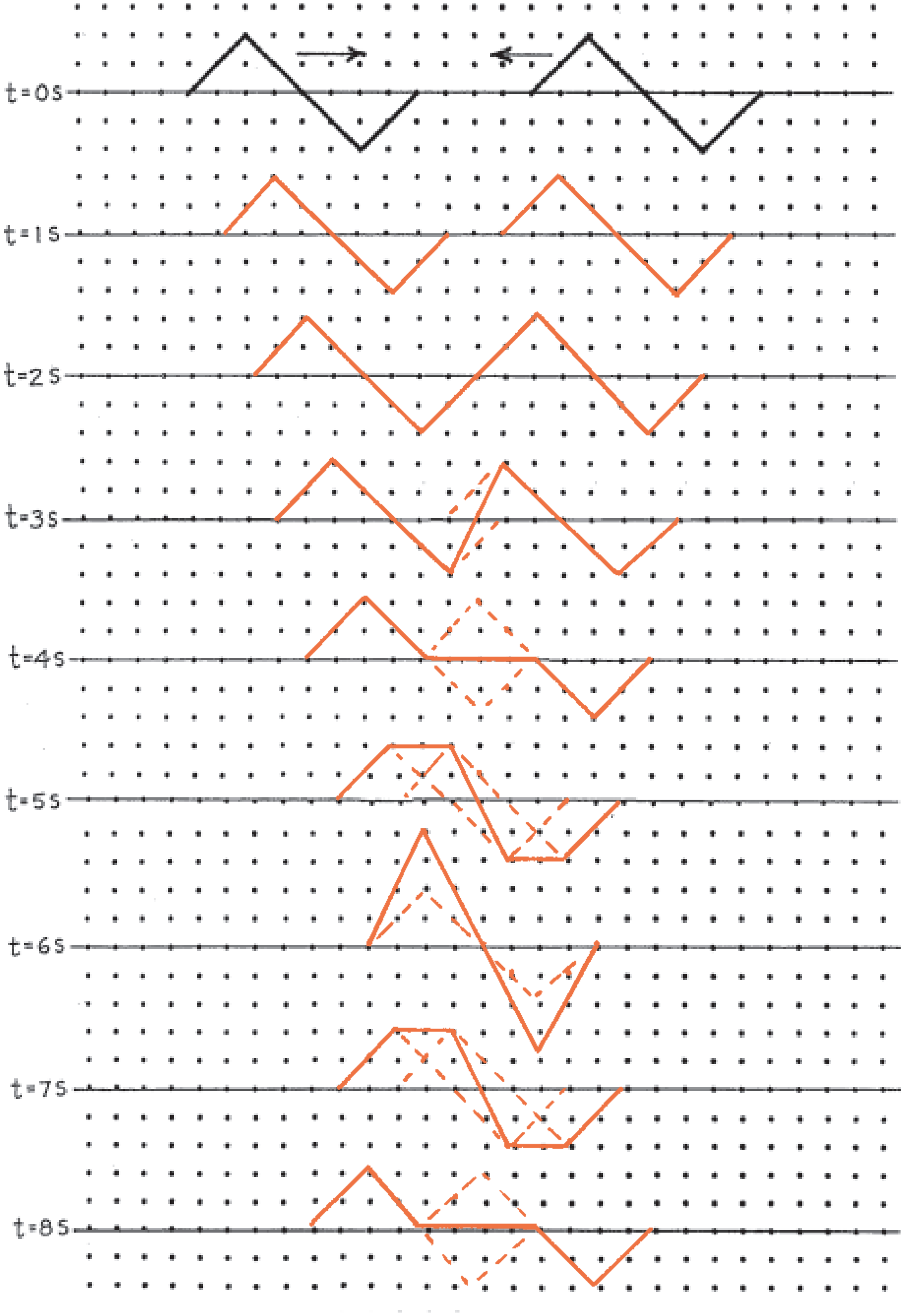
A pair of pulses travel toward each other at equal speeds. The composite waveforms as they pass through each other and interfere are shown at 1-second intervals. In the left column, note how the pulses interfere to produce the composite waveform (solid line). Make a similar construction for the two wave pulses in the right column. Like the pulses in the first column, they each travel at 1 space per second.



thanx to Marshall Ellenstein

CONCEPTUAL PHYSICS

Construct the composite waveforms at 1-second intervals for the two waves traveling toward each other at equal speed.



CONCEPTUAL PHYSICS

Name ______________ Class ______________ Date ______________

Chapter 25 Vibrations and Waves

Exercises

25.1 Vibration of a Pendulum (page 491)

1. The time it takes for one back-and-forth motion of a pendulum is called the period.

2. List the two things that determine the period of a pendulum.
length of the pendulum and the acceleration of gravity

3. Circle the letter of each statement about a pendulum that is true.

[✓ a.] A longer pendulum has a longer period.
[✓ b.] A shorter pendulum swings with a greater frequency.
[✓ c.] Mass does not affect the period of the pendulum.
d. All pendulums swing at the same rate.

25.2 Wave Description (pages 491–493)

4. What is simple harmonic motion?
the back-and-forth vibratory motion of a swinging pendulum

5. Is the following sentence true or false? A sine curve is a pictorial representation of a wave. true

6. Circle the letter that describes the source of all waves.

a. a temperature change
b. a change in pressure
[✓ c.] something that vibrates
d. an electrical current

Match each phrase with the correct word or words.

	Term		Definition
d	**7.** crest	a.	distance between successive identical parts of a wave
b	**8.** trough	b.	low point on a wave
e	**9.** amplitude	c.	vibrations per unit of time
a	**10.** wavelength	d.	high point on a wave
c	**11.** frequency	e.	distance from a midpoint to a crest
f	**12.** hertz	f.	unit of frequency

13. Is the following sentence true or false? As the frequency of a vibrating source increases, the period increases. false

25.3 Wave Motion (pages 493–494)

14. Describe the wave that forms and what is transmitted when a stone is dropped in a pond.
A wave is produced that moves out from the center in an expanding circle. The wave transmits energy but not matter.

15. Sounds waves are a(n) disturbance that travels through the air.

16. Circle the letter of each statement about sound waves in air that is true.

[✓ a.] They carry energy.
[✓ b.] Air is the medium they travel through.
[✓ c.] They are a disturbance that moves through the air.
[✓ d.] Air molecules are carried along with the wave.

25.4 Wave Speed (pages 495–496)

17. Is the following sentence true or false? The speed of a wave depends on the medium through which it travels. true

18. The speed of sound in air is about 330 m/s to 350 m/s.

19. Is the following sentence true or false? Sound travels faster in air than in water. false

20. Circle the letter of each wave property that is related.

[✓ a.] speed
[✓ b.] frequency
c. direction
[✓ d.] wavelength

21. Describe how to calculate the speed of a wave.

You multiply the wave's wavelength by its frequency.

22. Circle the letter of the equation used to calculate a wave's speed.

a. $v = \lambda p$
b. $v = \lambda t$
[✓ c.] $v = \lambda f$
d. $v = \lambda a$

23. The Greek letter lambda is often used to represent wavelength.

24. Is the following sentence true or false? The equation for calculating the speed of a wave does not apply to light waves. false

25. Describe how wavelength and frequency are related for sound waves.

They are inversely related.

25.5 Transverse Waves (pages 497)

26. Circle the letter that best describes a transverse wave.

a. The medium does not vibrate.
[✓ b.] The medium vibrates at right angles to the direction the wave travels.
c. The medium vibrates in the same direction the wave travels.
d. A sound wave.

27. Circle the letter of each example of a transverse wave.

[✓ a.] waves in the strings of instruments
[✓ b.] radio waves
[✓ c.] light waves
d. sound waves

25.6 Longitudinal Waves (page 497)

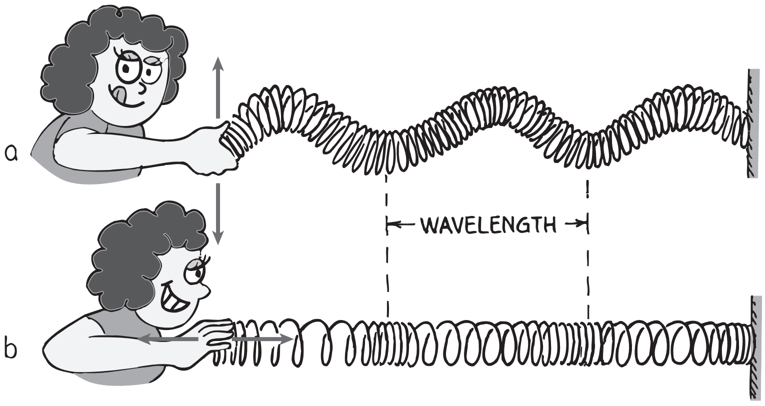
28. Describe the motion of the particles in a medium when a longitudinal wave passes through it.

The particles oscillate parallel to or along the direction of the wave.

29. What is an example of a longitudinal wave? sound

30. Identify the types of waves formed in part (a) and part (b) of the illustration below.

a. transverse b. longitudinal



25.7 Interference (pages 498–499)

31. A(n) interference pattern is a regular arrangement of places where wave effects are increased, decreased, or neutralized.

Match each term to its definition.

	Term	Definition
c	**32.** constructive interference	a. when crests overlap troughs and effects are reduced
a	**33.** destructive interference	b. when crests of one wave overlap the crests of another wave
d	**34.** out of phase	c. when crests overlap and effects add together
b	**35.** in phase	d. when crests and troughs overlap to produce zero amplitude

36. Describe when wave interference occurs.

Interference occurs when waves from different sources arrive at the same place simultaneously.

37. Is the following sentence true or false? Wave interference only occurs with transverse waves. true

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25.8 Standing Waves (pages 500–501)

38. Is the following sentence true or false? A wave that appears not to move is likely to be a standing wave. false

39. The points on a standing wave where no motion occurs are called nodes.

40. Circle the letter of each statement about antinodes that is true.

a. They seem not to move.

[✓ b.] They occur midway between nodes.

[✓ c.] location of largest amplitude

d. location of zero amplitude

41. Standing waves occur because of interference.

42. Describe the conditions necessary—in terms of wavelength—for a standing wave to form in a rope attached to a wall.

They form when a half wavelength or a multiple of a half wavelength fits exactly into the length of the vibrating medium.

43. Is the following sentence true or false? Standing waves can form in both transverse and longitudinal waves. true

25.9 The Doppler Effect (pages 501–503)

44. Is the following sentence true or false? A moving wave source does not affect the frequency of the wave encountered by an observer. false

45. Describe the Doppler effect.

the apparent change in frequency due to motion of the source (or receiver)

46. Circle the letter of each statement about the Doppler effect that is true.

[✓ a.] it occurs when a wave source moves toward an observer

[✓ b.] it occurs when an observer moves toward a wave source

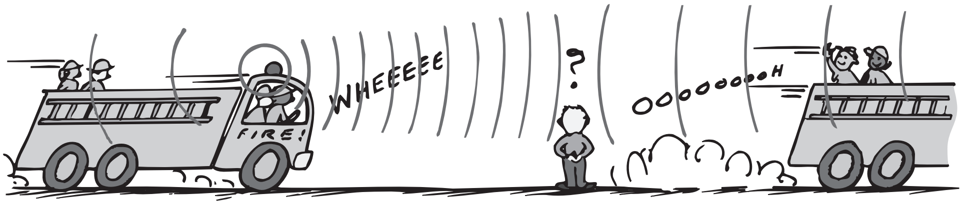
[✓ c.] it occurs when a wave source moves away an observer

[✓ d.] it occurs when an observer moves away from a wave source

47. Is the following sentence true or false? A higher frequency results when a wave source moves toward an observer. true

48. Two fire trucks with sirens on speed toward and away from an observer as shown below. Identify which truck produces a higher than normal siren frequency and which produces a lower than normal siren frequency.

higher: truck speeding toward listener; lower: truck speeding away



49. The blue shift and red shift refer to how the Doppler effect affects light waves.

50. A(n) increase in frequency is called a blue shift, while a(n) decrease is called a red shift.

25.10 Bow Waves (pages 504–505)

51. Is the following sentence true or false? Bow waves form a V-shaped wake in back of the moving source. true

52. Bow waves form when the wave source moves faster than the wave speed.

53. Is the following sentence true or false? The crests of bow waves overlap at their edges. true

54. Circle the letter that describes how increasing the speed of the wave source above the wave speed affects the shape of the bow wave that is formed.

a. The bow wave is unchanged.

[✓ b.] The bow wave has a narrower V shape.

c. The bow wave has a wider V shape.

d. The bow wave forms a straight line.

25.11 Shock Waves (pages 505–506)

55. A shock wave has the shape of a cone.

56. Circle the letter that describes the conditions needed for a shock wave to form.

a. An object moves at the speed of sound.

b. The wave speed exceeds the object's speed.

c. The wave speed equals the object's speed.

[✓ d.] An object moves faster than the speed of sound.

57. What is a sonic boom?

A sonic boom is the sharp crack heard when the shock wave that sweeps behind a supersonic aircraft reaches the listener.

58. Why don't we hear a sonic boom from a subsonic aircraft?

Because the sound wave crests reach our ears one at a time and are perceived as a continuous tone.

59. Is the following sentence true or false? A sonic boom is formed only at the moment an object breaks through the sound barrier. false

Chapter 25 Vibrations and Waves

Wave Speed

While watching the ocean surf roll in at the beach, you estimate the ocean wave frequency is about one wave every 10 s. You also estimate the average wavelength is about 25 m. What is the speed of the ocean waves?

Read and Understand

What information are you given?

Period = 10 s

Wavelength, $\lambda = 25$ m

Plan and Solve

What unknown are you trying to calculate?

Wave speed, $v = ?$

What formulas contains the given quantity and the unknown?

$$F = \frac{1}{T} \text{ and } v = \lambda f$$

Substitute the known values and solve.

$$f = \frac{1}{10\text{ s}} = 0.1\text{ s}^{-1}$$

$$v = \lambda f = (25\text{ m})(0.1\text{ s}^{-1}) = 2.5\text{ m/s}$$

Look Back and Check

Is your answer reasonable?

Yes, the calculated speed of 2.5 m/s seems reasonable for an ocean wave.

Math Practice

On a separate sheet of paper, solve the following problems.

1. One wave passes by a pier every 5 s. If the wavelength of the wave is 12 m, what is the wave speed?

   $f = \frac{1}{5}$ Hz; $v = \lambda f = (12\text{ m})(\frac{1}{5}\text{ s}^{-1}) = 2.4\text{ m/s}$

2. A sound wave has a speed of 340 m/s in air. If the wave has a frequency of 185 Hz, what is its wavelength?

   $\lambda = \frac{v}{f} = \frac{340\text{ m/s}}{185\text{ s}^{-1}} = 1.8\text{ m}$

3. A sound wave travels at 345 m/s in air and has a wavelength of 1.9 m. What is the period of the wave?

   $f = \frac{v}{\lambda} = \frac{340\text{ m/s}}{1.9\text{ m}} = 180\text{ Hz},$

   $T = \frac{1}{f} = \frac{1}{180\text{ s}^{-1}} = 0.0056\text{ s}$