THE BIG IDEA

Electric current is related to the voltage that produces it, and the resistance that opposes it.

Voltage produces a flow of charge, or *current*, within a conductor. The flow is restrained by the *resistance* it encounters. The rate at which energy is transferred by electric current is *power*.

34.1 Flow of Charge

When the ends of an electric conductor are at different electric potentials, charge flows from one end to the other.

34.1 Flow of Charge

Heat flows through a conductor when a temperature difference exists. Heat flows from higher temperature to lower temperature.

When temperature is at equilibrium, the flow of heat ceases.

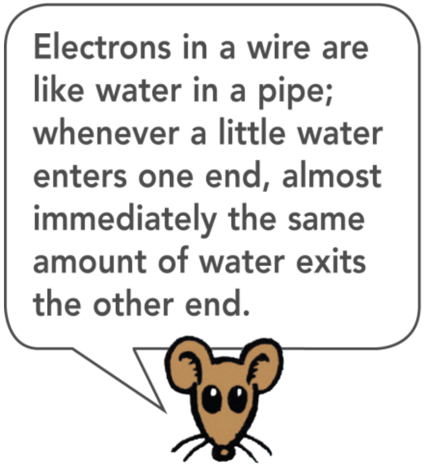
34.1 Flow of Charge

Charge flows in a similar way. Charge flows when there is a **potential difference,** or difference in potential (voltage), between the ends of a conductor. The flow continues until both ends reach the same potential.

When there is no potential difference, there is no longer a flow of charge through the conductor.

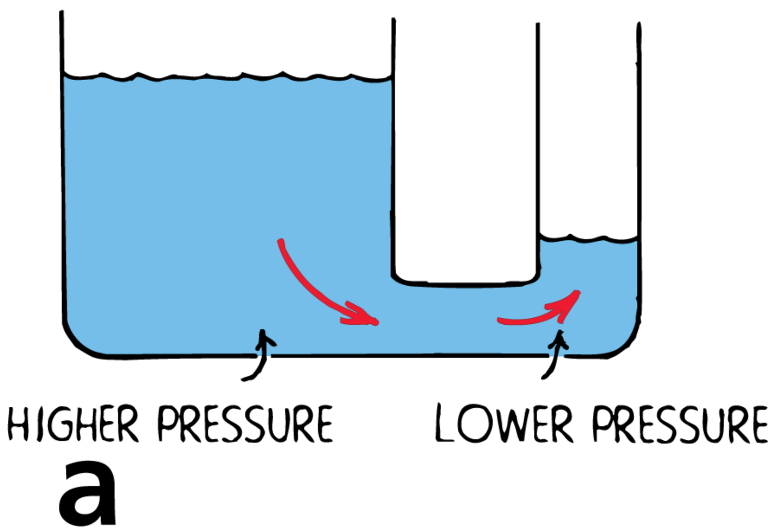
To attain a sustained flow of charge in a conductor, one end must remain at a higher potential than the other.

The situation is analogous to the flow of water.



34.1 Flow of Charge

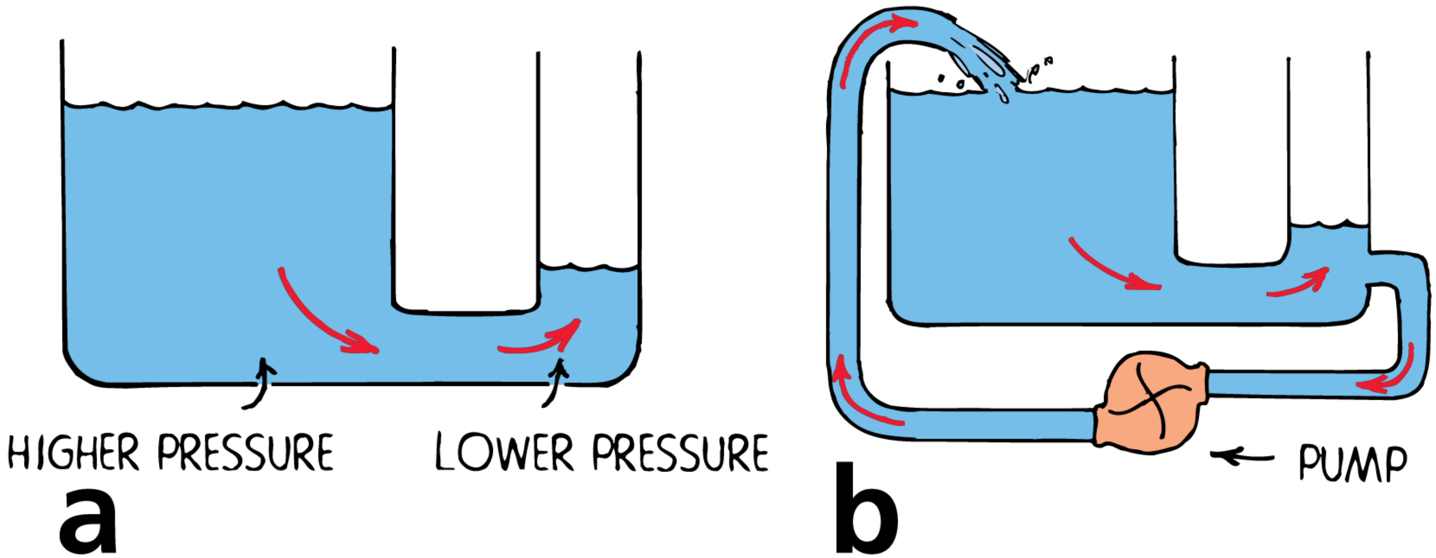
a. Water flows from higher pressure to lower pressure. The flow will cease when the difference in pressure ceases.



34.1 Flow of Charge

a. Water flows from higher pressure to lower pressure. The flow will cease when the difference in pressure ceases.

b. Water continues to flow because a difference in pressure is maintained with the pump. The same is true of electric current.



34.1 Flow of Charge

CONCEPT CHECK

What happens when the ends of a conductor are at different electrical potentials?

34.2 Electric Current

A current-carrying wire has a net electric charge of zero.

34.2 Electric Current

Electric current is the flow of electric charge.

In solid conductors, electrons carry the charge through the circuit because they are free to move throughout the atomic network.

These electrons are called *conduction electrons.*

Protons are bound inside atomic nuclei, locked in fixed positions.

In fluids, such as the electrolyte in a car battery, positive and negative ions as well as electrons may flow.

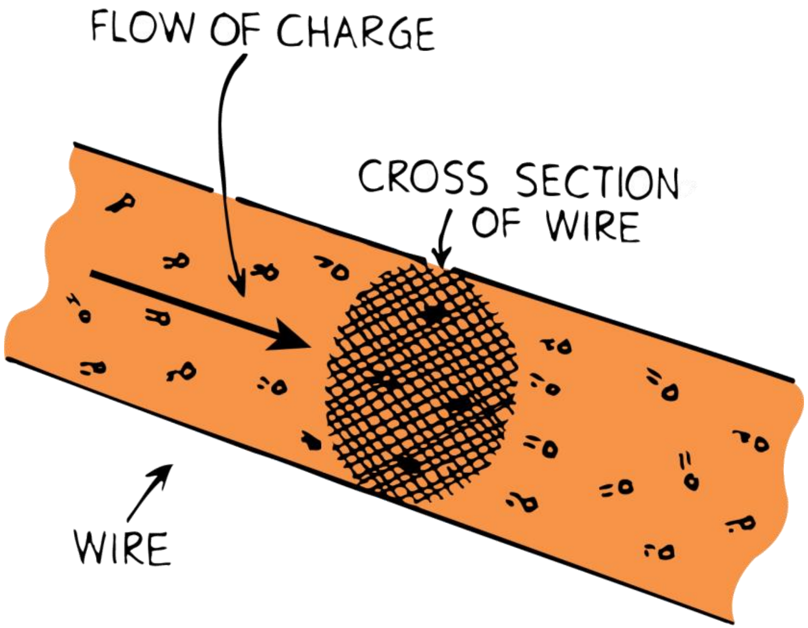
34.2 Electric Current

Measuring Current

Electric current is measured in **amperes,** symbol A.

An ampere is the flow of 1 coulomb of charge per second.

When the flow of charge past any cross section is 1 coulomb (6.24 billion billion electrons) per second, the current is 1 ampere.



34.2 Electric Current

Net Charge of a Wire

While the current is flowing, negative electrons swarm through the atomic network of positively charged atomic nuclei.

Under ordinary conditions, the number of electrons in the wire is equal to the number of positive protons in the atomic nuclei.

As electrons flow, the number entering is the same as the number leaving, so the net charge is normally zero at every moment.

34.2 Electric Current

CONCEPT CHECK

What is the net flow of electric charge in a current-carrying wire?

34.3 Voltage Sources

Voltage sources such as batteries and generators supply energy that allows charges to move steadily.

34.3 Voltage Sources

Charges do not flow unless there is a potential difference.

Something that provides a potential difference is known as a **voltage source.**

Batteries and generators are capable of maintaining a continuous flow of electrons.

34.3 Voltage Sources

Steady Voltage Sources

In a battery, a chemical reaction releases electrical energy.

Generators—such as the alternators in automobiles—convert mechanical energy to electrical energy.

The electrical potential energy produced is available at the terminals of the battery or generator.

34.3 Voltage Sources

The potential energy per coulomb of charge available to electrons moving between terminals is the voltage.

The voltage provides the "electric pressure" to move electrons between the terminals in a circuit.

34.3 Voltage Sources

Power utilities use electric generators to provide the 120 volts delivered to home outlets.

The alternating potential difference between the two holes in the outlet averages 120 volts.

When the prongs of a plug are inserted into the outlet, an average electric “pressure” of 120 volts is placed across the circuit.

This means that 120 joules of energy is supplied to each coulomb of charge that is made to flow in the circuit.

34.3 Voltage Sources

Distinguishing Between Current and Voltage

There is often some confusion between charge flowing *through* a circuit and voltage being impressed *across* a circuit.

34.3 Voltage Sources

Consider a long pipe filled with water.

- Water will flow *through* the pipe if there is a difference in pressure *across* the pipe or between its ends.
- Water flows from high pressure to low pressure.

Similarly, charges flow *through* a circuit because of an applied voltage *across* the circuit.

- You don’t say that voltage flows through a circuit.
- Voltage doesn’t go anywhere, for it is the charges that move.
- Voltage causes current.

34.3 Voltage Sources

CONCEPT CHECK

What are two voltage sources used to provide the energy that allows charges to move steadily?

34.4 Electric Resistance

The resistance of a wire depends on the *conductivity* of the material used in the wire (that is, how well it conducts) and also on the thickness and length of the wire.

34.4 Electric Resistance

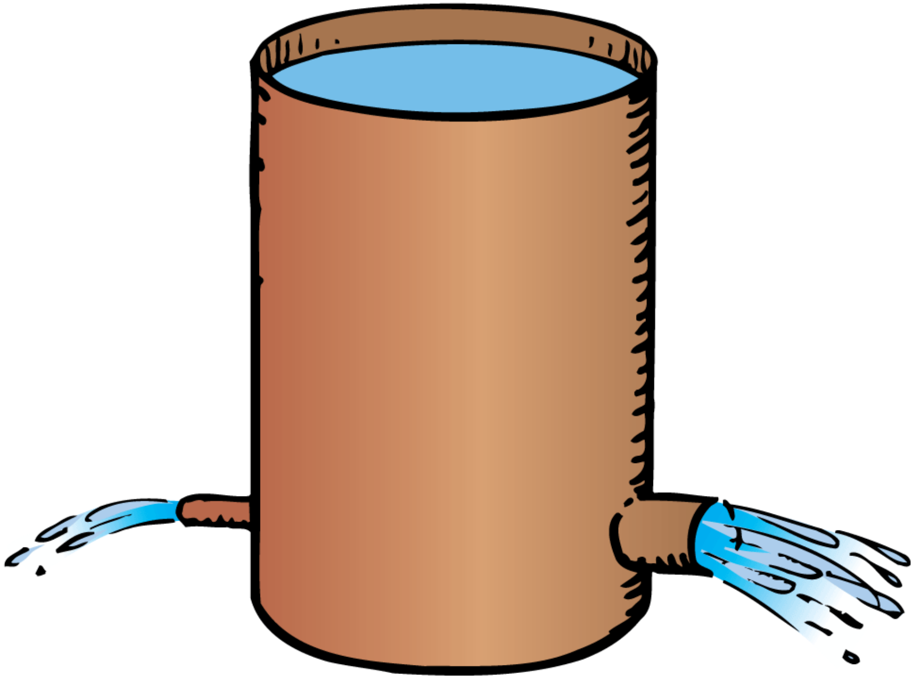
The amount of charge that flows in a circuit depends on the voltage provided by the voltage source.

The current also depends on the resistance that the conductor offers to the flow of charge—the **electric resistance.**

This is similar to the rate of water flow in a pipe, which depends on the pressure difference and on the resistance of the pipe.

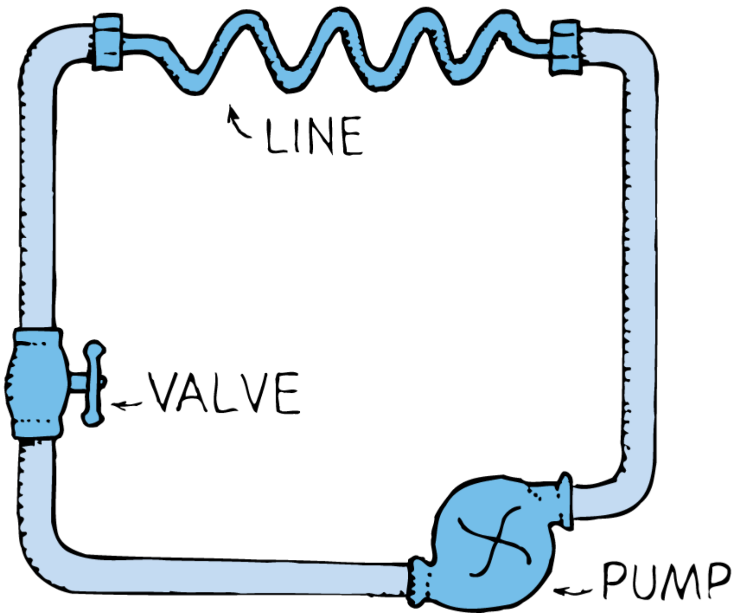
34.4 Electric Resistance

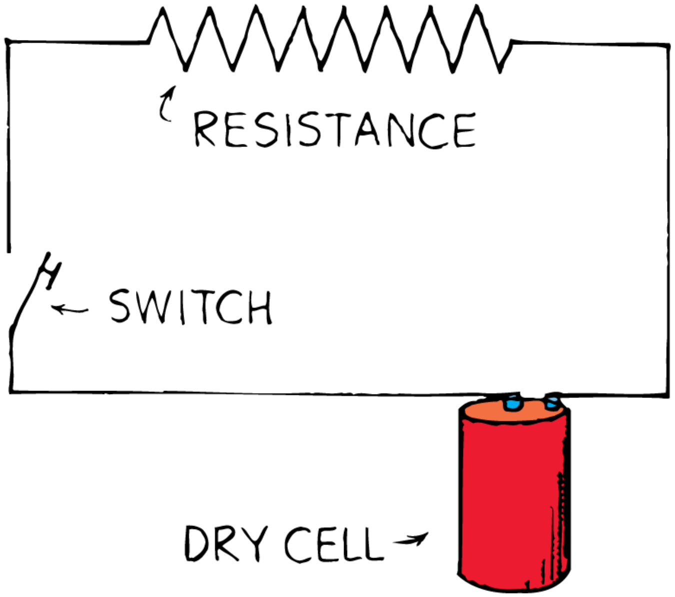
For a given pressure, more water passes through a large pipe than a small one. Similarly, for a given voltage, more electric current passes through a large-diameter wire than a small-diameter one.



34.4 Electric Resistance

A simple hydraulic circuit is analogous to an electric circuit.

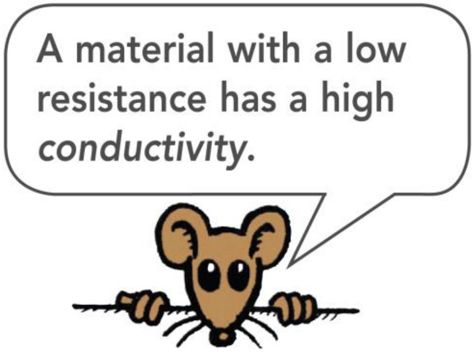




34.4 Electric Resistance

The resistance of a wire depends on the *conductivity* of the material in the wire and on the thickness and length of the wire.

- Thick wires have less resistance than thin wires.
- Longer wires have more resistance than short wires.
- Electric resistance also depends on temperature. For most conductors, increased temperature means increased resistance.



34.4 Electric Resistance

The resistance of some materials becomes zero at very low temperatures, a phenomenon known as **superconductivity.**

Certain metals acquire superconductivity (zero resistance to the flow of charge) at temperatures near absolute zero.

Superconductivity at “high” temperatures (above 100 K) has been found in a variety of nonmetallic compounds.

In a superconductor, the electrons flow indefinitely.

34.4 Electric Resistance

CONCEPT CHECK

What factors affect the resistance of a wire?

34.5 Ohm's Law

Ohm's law states that the current in a circuit is directly proportional to the voltage impressed across the circuit, and is inversely proportional to the resistance of the circuit.

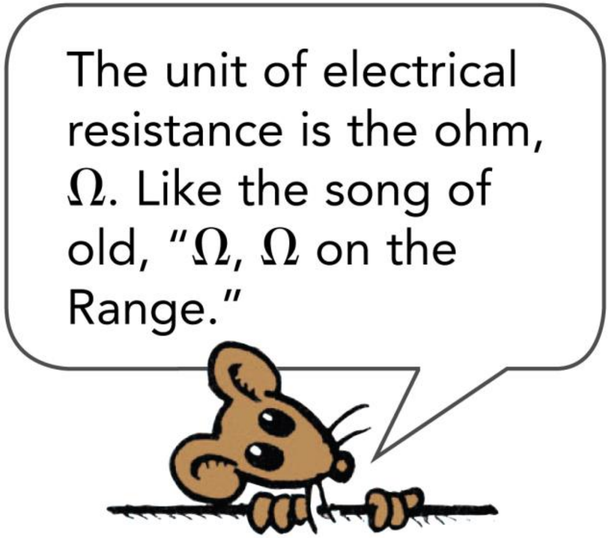
34.5 Ohm's Law

Electric resistance is measured in units called **ohms.**

Georg Simon Ohm, a German physicist, tested wires in circuits to see what effect the resistance of the wire had on the current.

The relationship among voltage, current, and resistance is called **Ohm's law.**

$$\text{current} = \frac{\text{voltage}}{\text{resistance}}$$



34.5 Ohm's Law

For a given circuit of constant resistance, current and voltage are proportional.

Twice the current flows through a circuit for twice the voltage across the circuit. The greater the voltage, the greater the current.

If the resistance is doubled for a circuit, the current will be half what it would be otherwise.

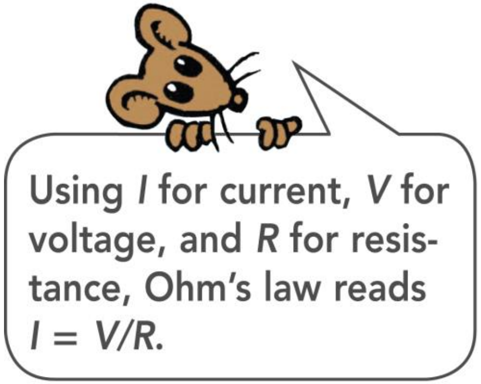
34.5 Ohm's Law

The relationship among the units of measurement is:

$$1 \text{ ampere} = 1 \frac{\text{volt}}{\text{ohm}}$$

A potential difference of 1 volt impressed across a circuit that has a resistance of 1 ohm will produce a current of 1 ampere.

If a voltage of 12 volts is impressed across the same circuit, the current will be 12 amperes.



34.5 Ohm's Law

The resistance of a typical lamp cord is much less than 1 ohm, while a typical light bulb has a resistance of about 100 ohms.

An iron or electric toaster has a resistance of 15 to 20 ohms.

The low resistance permits a large current, which produces considerable heat.

34.5 Ohm’s Law

Current inside electric devices is regulated by circuit elements called *resistors.*

The stripes on these resistors are color coded to indicate the resistance in ohms.

34.5 Ohm's Law

think!

How much current is drawn by a lamp that has a resistance of 100 ohms when a voltage of 50 volts is impressed across it?

34.5 Ohm's Law

think!

How much current is drawn by a lamp that has a resistance of 100 ohms when a voltage of 50 volts is impressed across it?

Answer:

$$\text{Current} = \frac{\text{voltage}}{\text{resistance}} = \frac{50\ \text{V}}{100\ \Omega} = 0.5\ \text{A}$$

34.5 Ohm's Law

CONCEPT CHECK

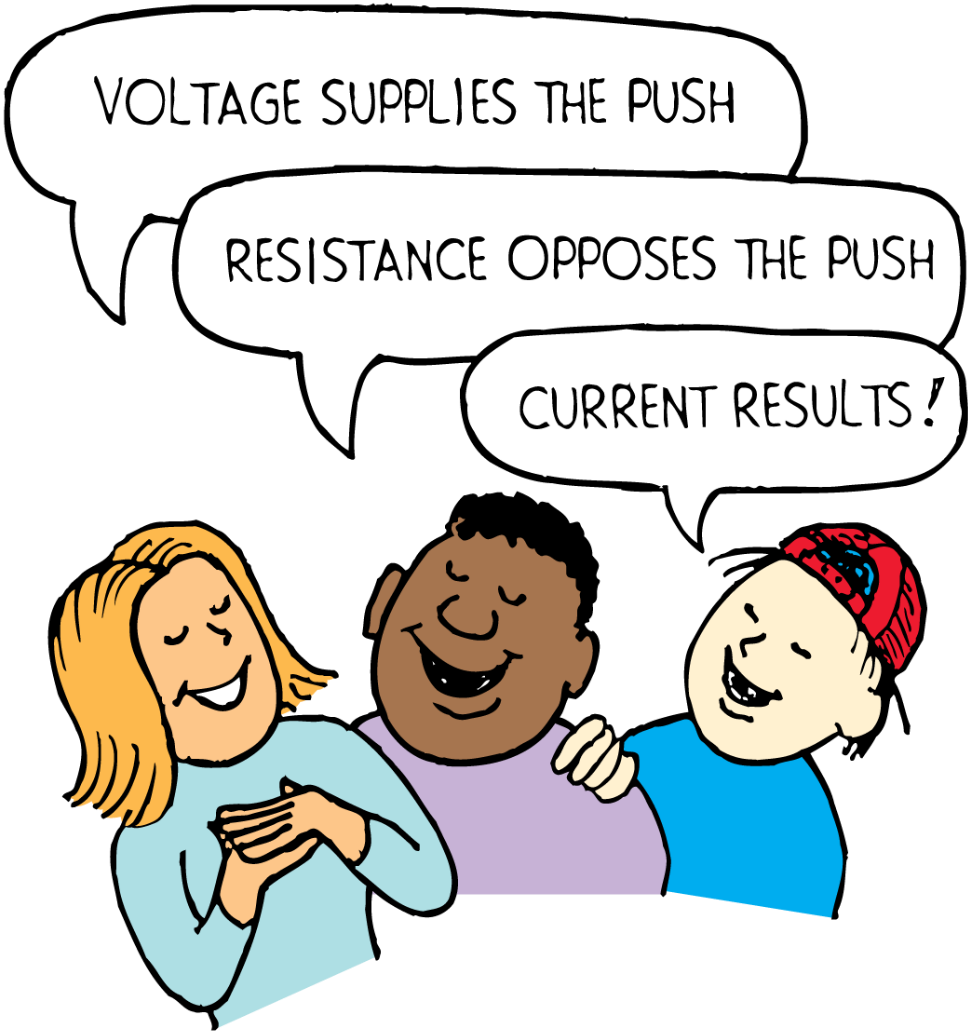
What does Ohm's law state?

34.6 Ohm's Law and Electric Shock

The damaging effects of electric shock are the result of current passing through the body.

34.6 Ohm's Law and Electric Shock

From Ohm's law, we can see that current depends on the voltage applied, and also on the electric resistance of the human body.



34.6 Ohm's Law and Electric Shock

The Body's Resistance

Your body's resistance ranges from about 100 ohms if soaked with salt water to about 500,000 ohms if your skin is very dry.

Touch the electrodes of a battery with dry fingers and your resistance to the flow of charge would be about 100,000 ohms.

You would not feel 12 volts, and 24 volts would just barely tingle.

With moist skin, however, 24 volts could be quite uncomfortable.

34.6 Ohm's Law and Electric Shock

Table 34.1 Effect of Various Electric Currents on the Body

Current (amperes)	Effect
0.001	Can be felt
0.005	Painful
0.010	Involuntary muscle contractions (spasms)
0.015	Loss of muscle control
0.070	If through the heart, serious disruption; probably fatal if current lasts for more than 1 second

34.6 Ohm's Law and Electric Shock

Many people are killed each year by current from common 120-volt electric circuits.

Touch a faulty 120-volt light fixture while standing on the ground and there is a 120-volt "pressure" between you and the ground.

The soles of your shoes normally provide a very large resistance, so the current would probably not be enough to do serious harm.

34.6 Ohm's Law and Electric Shock

If you are standing barefoot in a wet bathtub, the resistance between you and the ground is very small.

Your overall resistance is so low that the 120-volt potential difference may produce a harmful current through your body.

Drops of water that collect around the on/off switches of devices such as a hair dryer can conduct current to the user.

34.6 Ohm's Law and Electric Shock

Although distilled water is a good insulator, the ions in ordinary water greatly reduce the electric resistance.

There is also usually a layer of salt on your skin, which when wet lowers your skin resistance to a few hundred ohms or less.

Handling electric devices while taking a bath is extremely dangerous.

34.6 Ohm’s Law and Electric Shock

Handling a wet hair dryer can be like sticking your fingers into a live socket.

34.6 Ohm's Law and Electric Shock

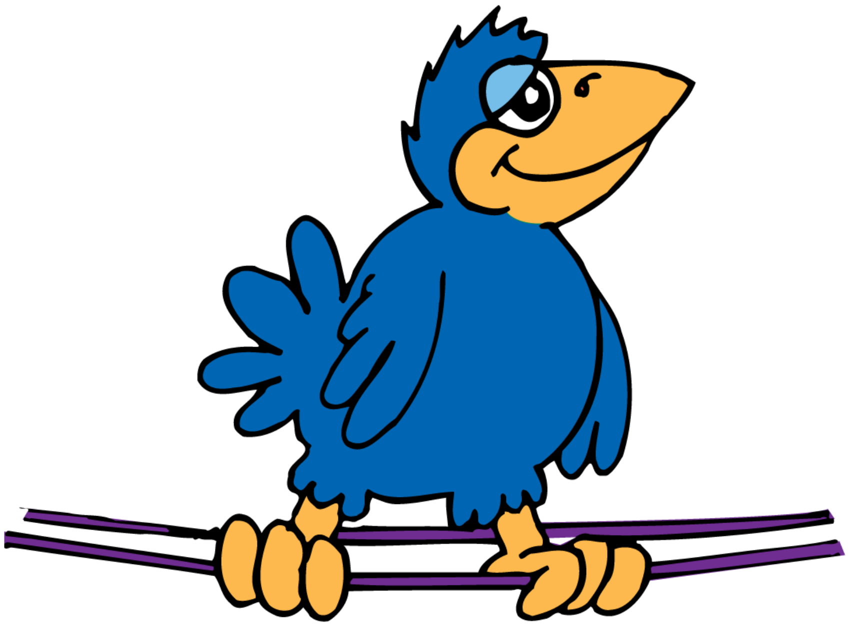
High-Voltage Wires

You probably have seen birds perched on high-voltage wires.

Every part of the bird's body is at the same high potential as the wire, and it feels no ill effects.

For the bird to receive a shock, there must be a *difference* in potential between one part of its body and another part.

Most of the current will then pass along the path of least electric resistance connecting these two points.



34.6 Ohm's Law and Electric Shock

Suppose you fall from a bridge and manage to grab onto a high-voltage power line, halting your fall.

If you touch nothing else of different potential, you will receive no shock, even if the wire is thousands of volts above ground potential.

No charge will flow from one hand to the other because there is no appreciable difference in electric potential between your hands.

34.6 Ohm's Law and Electric Shock

Ground Wires

Mild shocks occur when the surfaces of appliances are at an electric potential different from other nearby devices.

If you touch surfaces of different potentials, you become a pathway for current.

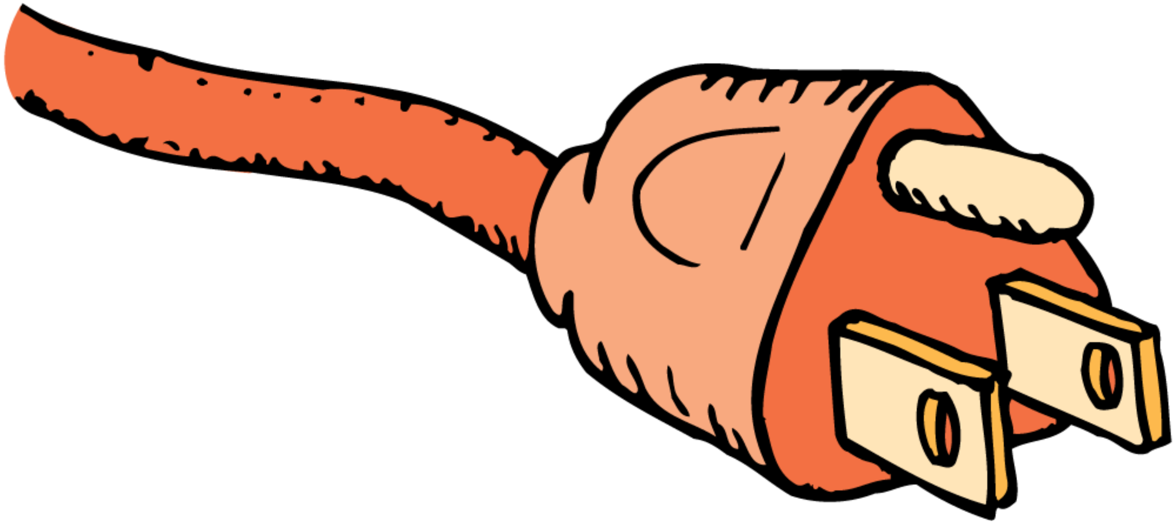
To prevent this, electric appliances are connected to a ground wire, through the round third prong of a three-wire electric plug.

34.6 Ohm’s Law and Electric Shock

All ground wires in all plugs are connected together through the wiring system of the house.

The two flat prongs are for the current-carrying double wire.

If the live wire accidentally comes in contact with the metal surface of an appliance, the current will be directed to ground rather than shocking you if you handle it.



34.6 Ohm’s Law and Electric Shock

Health Effects

One effect of electric shock is to overheat tissues in the body or to disrupt normal nerve functions.

It can upset the nerve center that controls breathing.

34.6 Ohm's Law and Electric Shock

think!

If the resistance of your body were 100,000 ohms, what would be the current in your body when you touched the terminals of a 12-volt battery?

34.6 Ohm's Law and Electric Shock

think!

If the resistance of your body were 100,000 ohms, what would be the current in your body when you touched the terminals of a 12-volt battery?

Answer:

$$\text{Current} = \frac{\text{voltage}}{\text{resistance}} = \frac{12\ \text{V}}{100{,}000\ \Omega} = 0.00012\ \text{A (quite harmless)}$$

34.6 Ohm's Law and Electric Shock

think!

If your skin were very moist, so that your resistance was only 1000 ohms, and you touched the terminals of a 24-volt battery, how much current would you draw?

34.6 Ohm's Law and Electric Shock

think!

If your skin were very moist, so that your resistance was only 1000 ohms, and you touched the terminals of a 24-volt battery, how much current would you draw?

Answer:

You would draw $\frac{24\ \text{V}}{1000\ \Omega}$

or 0.024 A, a dangerous amount of current!

34.6 Ohm's Law and Electric Shock

CONCEPT CHECK

What causes the damaging effects of electric shock?

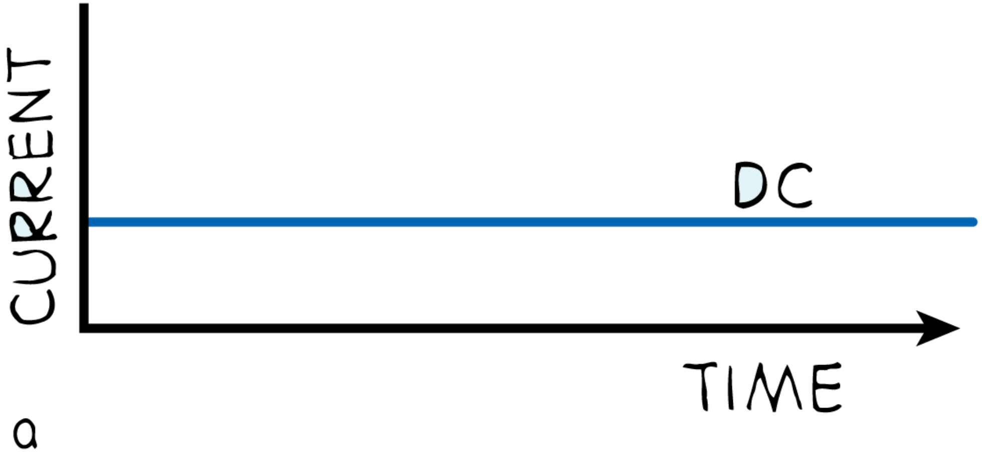
34.7 Direct Current and Alternating Current

Electric current may be DC or AC.

34.7 Direct Current and Alternating Current

By DC, we mean **direct current,** which refers to a flow of charge that *always flows in one direction.*

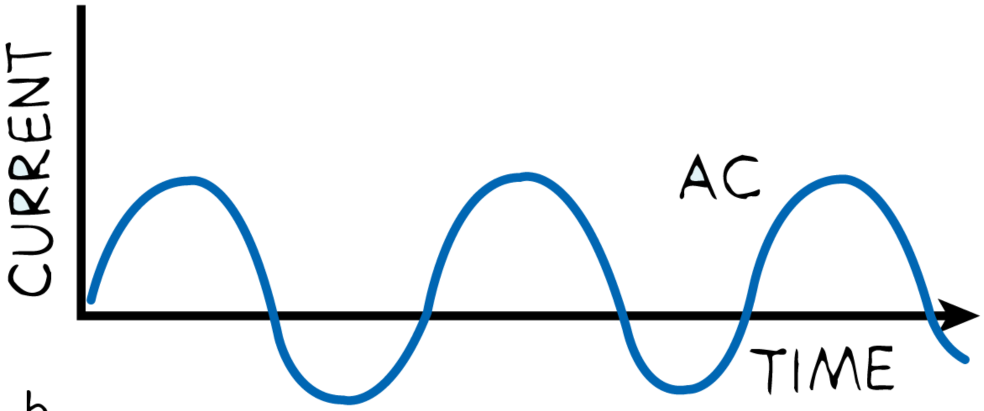
- A battery produces direct current in a circuit because the terminals of the battery always have the same sign of charge.
- Electrons always move through the circuit from the negative terminal toward the positive terminal.
- Even if the current moves in unsteady pulses, so long as it moves in one direction only, it is DC.



34.7 Direct Current and Alternating Current

Alternating current (AC), as the name implies, is electric current that repeatedly reverses direction.

- Electrons in the circuit move first in one direction and then in the opposite direction.
- They alternate back and forth about relatively fixed positions.
- This is accomplished by alternating the polarity of voltage at the generator or other voltage source.



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34.7 Direct Current and Alternating Current

Voltage Standards

Voltage of AC in North America is normally 120 volts.

In the early days of electricity, higher voltages burned out the filaments of electric light bulbs.

Power plants in the United States prior to 1900 adopted 110 volts (or 115 or 120 volts) as standard.

34.7 Direct Current and Alternating Current

By the time electricity became popular in Europe, light bulbs were available that would not burn out so fast at higher voltages.

Power transmission is more efficient at higher voltages, so Europe adopted 220 volts as their standard.

The United States stayed with 110 volts (today, officially 120 volts) because of the installed base of 110-volt equipment.

34.7 Direct Current and Alternating Current

Three-Wire Service

Although lamps in an American home operate on 110–120 volts, electric stoves and other appliances operate on 220–240 volts.

Most electric service in the United States is three-wire:

- one wire at 120 volts positive
- one wire at zero volts (neutral)
- one wire at a negative 120 volts

34.7 Direct Current and Alternating Current

In AC, the positive and negative alternate at 60 hertz. A wire that is positive at one instant is negative 1/120 of a second later.

Most home appliances are connected between the neutral wire and either of the other two wires, producing 120 volts.

When the plus-120 is connected to the minus-120, it produces a 240-volt difference—just right for electric stoves, air conditioners, and clothes dryers.

34.7 Direct Current and Alternating Current

The popularity of AC arises from the fact that electrical energy in the form of AC can be transmitted great distances.

Easy voltage step-ups result in lower heat losses in the wires.

The primary use of electric current, whether DC or AC, is to transfer energy from one place to another.

34.7 Direct Current and Alternating Current

CONCEPT CHECK

What are the two types of electric current?

34.8 Converting AC to DC

With an AC-DC converter, you can operate a battery-run device on AC instead of batteries.

34.8 Converting AC to DC

The current in your home is AC. The current in a battery-operated device, such as a laptop computer or cell phone, is DC.

With an AC-DC converter, you can operate a battery-run device on AC instead of batteries.

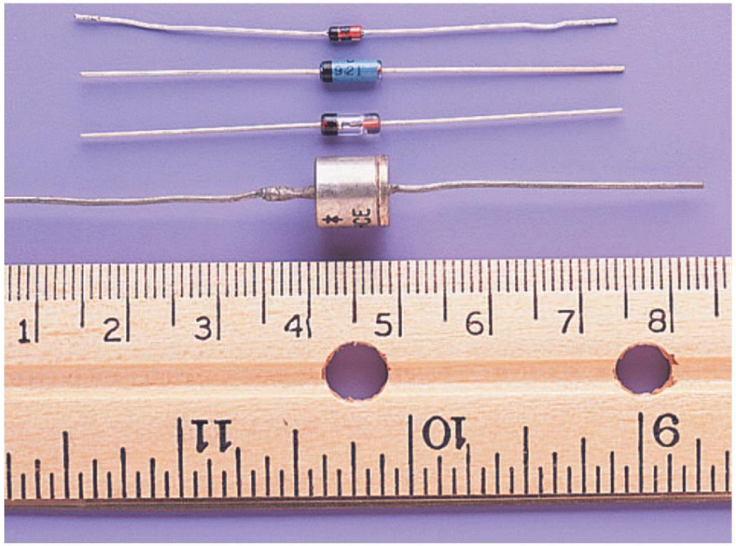
34.8 Converting AC to DC

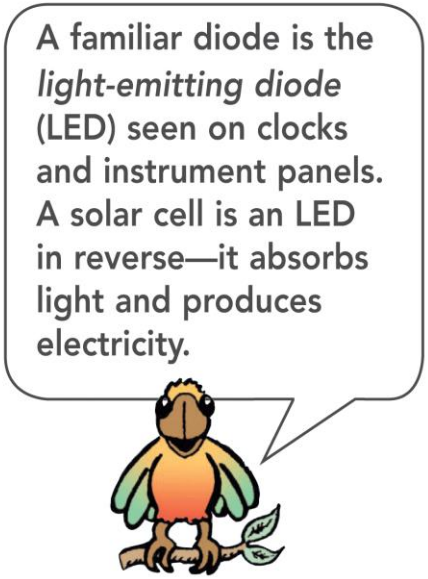
A converter uses a transformer to lower the voltage and a **diode,** an electronic device that allows electron flow in only one direction.

Since alternating current vibrates in two directions, only half of each cycle will pass through a diode.

The output is a rough DC, off half the time.

To maintain continuous current while smoothing the bumps, a capacitor is used.





34.8 Converting AC to DC

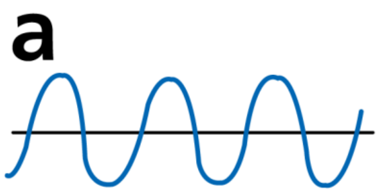
Recall that a capacitor acts as a storage reservoir for charge.

Just as it takes time to raise or lower the water level in a reservoir, it takes time to add or remove electrons from the capacitor.

A capacitor therefore produces a retarding effect on changes in current flow and smoothes the pulsed output.

34.8 Converting AC to DC

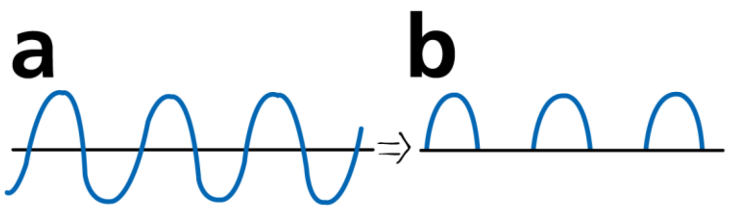
a. When input to a diode is AC,



34.8 Converting AC to DC

a. When input to a diode is AC,

b. output is pulsating DC.

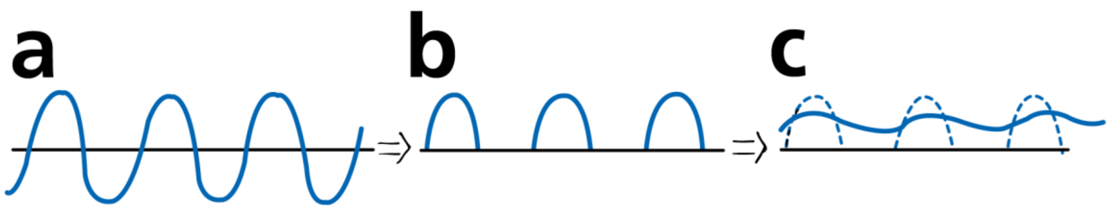


34.8 Converting AC to DC

a. When input to a diode is AC,

b. output is pulsating DC.

c. Charging and discharging of a capacitor provides continuous and smoother current.



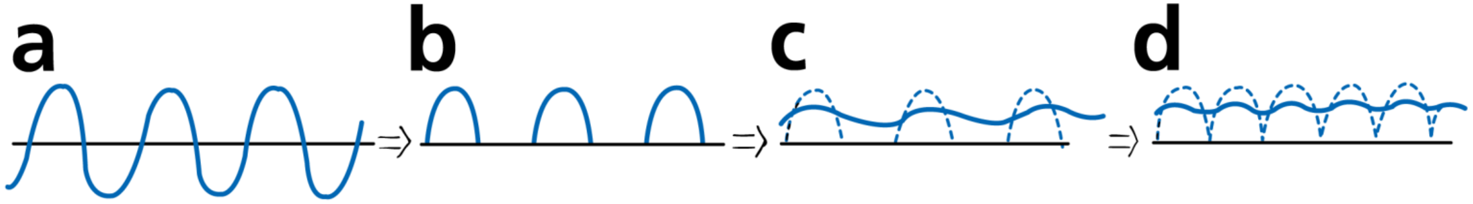
34.8 Converting AC to DC

a. When input to a diode is AC,

b. output is pulsating DC.

c. Charging and discharging of a capacitor provides continuous and smoother current.

d. In practice, a pair of diodes is used so there are no gaps in current output.



34.8 Converting AC to DC

CONCEPT CHECK

How can you operate a battery-run device on AC?

34.9 The Speed of Electrons in a Circuit

In a current-carrying wire, collisions interrupt the motion of the electrons so that their actual *drift speed*, or *net speed* through the wire due to the field, is extremely low.

34.9 The Speed of Electrons in a Circuit

When you flip on the light switch on your wall and the circuit is completed, the light bulb appears to glow immediately.

Energy is transported through the connecting wires at nearly the speed of light.

The electrons that make up the current, however, do not move at this high speed.

34.9 The Speed of Electrons in a Circuit

The electrons inside a metal wire have an average speed of a few million kilometers per hour due to their thermal motion.

This does not produce a current because the motion is random. There is no net flow in any one direction.

When a battery or generator is connected, an electric field is established inside the wire.

34.9 The Speed of Electrons in a Circuit

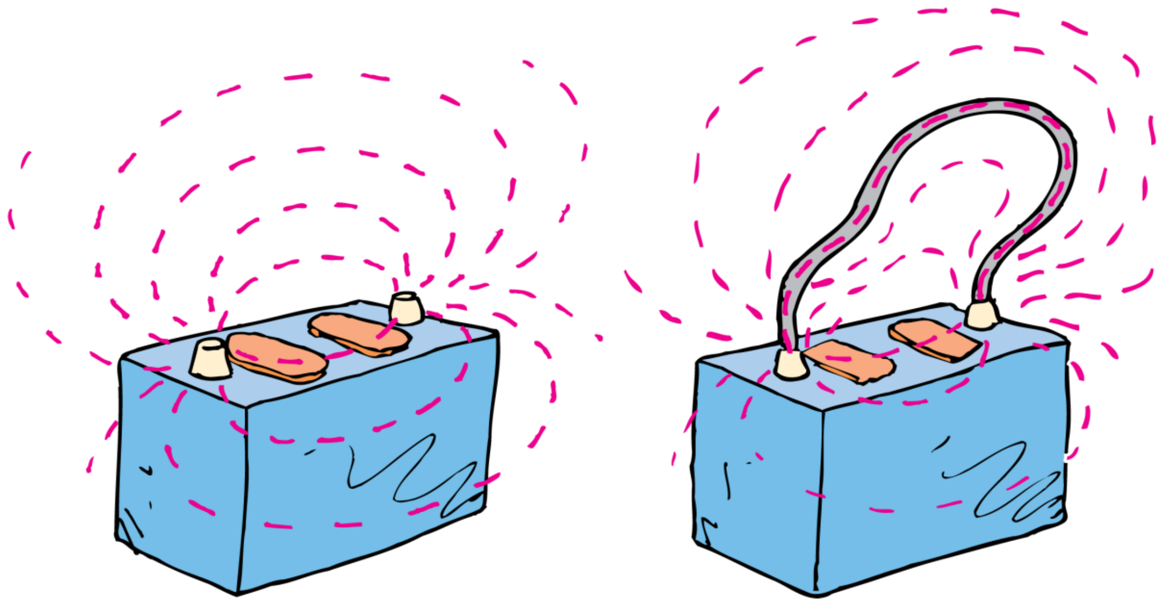
A pulsating electric field can travel through a circuit at nearly the speed of light.

The electrons continue their random motions in all directions while simultaneously being nudged along the wire by the electric field.

The conducting wire acts as a “pipe” for electric field lines. Inside the wire, the electric field is directed along the wire.

34.9 The Speed of Electrons in a Circuit

The electric field lines between the terminals of a battery are directed through a conductor, which joins the terminals.



34.9 The Speed of Electrons in a Circuit

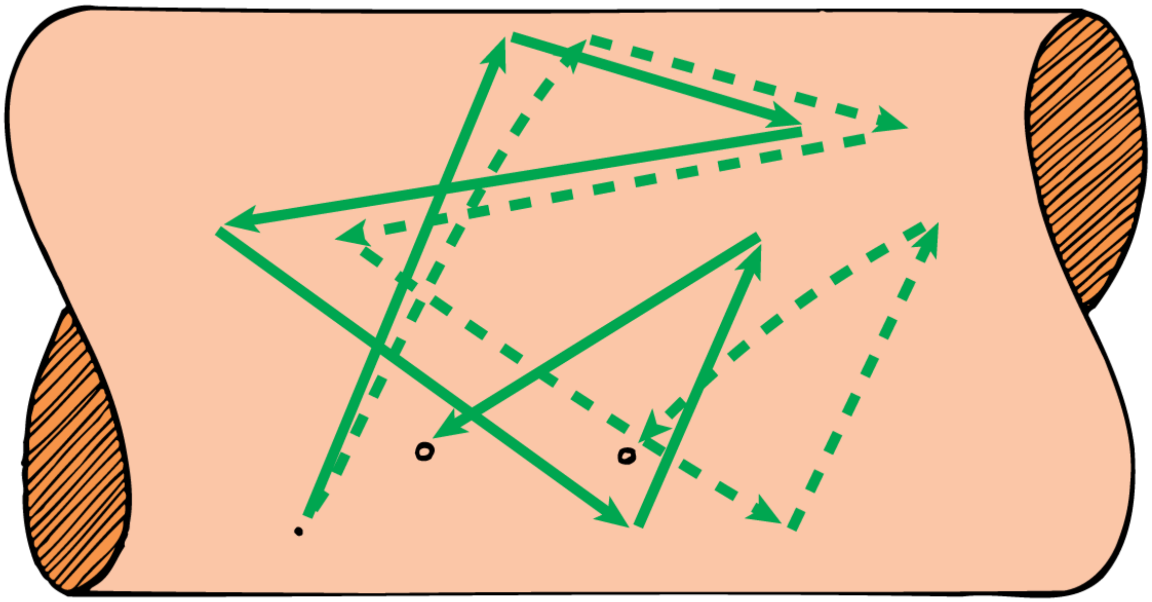
Conduction electrons are accelerated by the field.

Before the electrons gain appreciable speed, they "bump into" metallic ions and transfer some of their kinetic energy.

- Collisions interrupt the motion of the electrons. Their actual *drift speed*, or *net speed* through the wire, is extremely low.
- In the electric system of an automobile, electrons have a net average drift speed of about 0.01 cm/s.

34.9 The Speed of Electrons in a Circuit

The solid lines depict a random path of an electron bouncing off atoms in a conductor. The dashed lines show an exaggerated view of how this path changes when an electric field is applied. The electron drifts toward the right with an average speed less than a snail's pace.



34.9 The Speed of Electrons in a Circuit

In an AC circuit, the conduction electrons don't make any net progress in any direction.

- In a single cycle they drift a tiny fraction of a centimeter in one direction, and then the same distance in the opposite direction.
- They oscillate rhythmically about relatively fixed positions.
- On a conventional telephone, it is the *pattern* of oscillating motion that is carried at nearly the speed of light.
- The electrons in the wires vibrate to the rhythm of the traveling pattern.

34.9 The Speed of Electrons in a Circuit

CONCEPT CHECK

Why is the drift speed of electrons in a current-carrying wire extremely low?

34.10 The Source of Electrons in a Circuit

The source of electrons in a circuit is the conducting circuit material itself.

34.10 The Source of Electrons in a Circuit

You can buy a water hose that is empty of water, but you can't buy a piece of wire, an "electron pipe," that is empty of electrons.

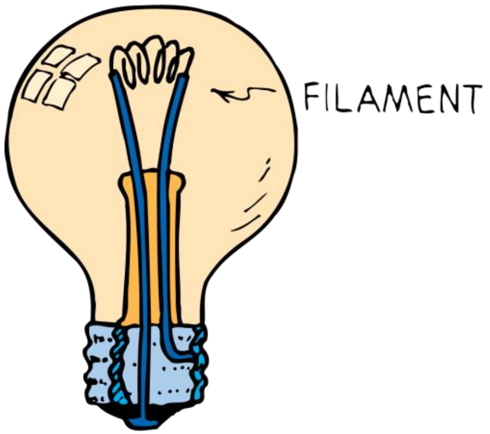
The source of electrons in a circuit is the conducting circuit material itself.

Electrons do not travel appreciable distances through a wire in an AC circuit. They vibrate to and fro about relatively fixed positions.

34.10 The Source of Electrons in a Circuit

When you plug a lamp into an AC outlet, *energy* flows from the outlet into the lamp, not electrons.

Energy is carried by the electric field and causes a vibratory motion of the electrons that already exist in the lamp filament.



Most of this electrical energy appears as heat, while some of it takes the form of light.

Power utilities do not sell electrons. They sell *energy.* You supply the electrons.

34.10 The Source of Electrons in a Circuit

When you are jolted by an AC electric shock, the electrons making up the current in your body originate in your body.

Electrons do not come out of the wire and through your body and into the ground; energy does.

The energy simply causes free electrons in your body to vibrate in unison.

Small vibrations tingle; large vibrations can be fatal.

34.10 The Source of Electrons in a Circuit

CONCEPT CHECK

What is the source of electrons in a circuit?

34.11 Electric Power

Electric power is equal to the product of current and voltage.

34.11 Electric Power

Unless it is in a superconductor, a charge moving in a circuit expends energy.

This may result in heating the circuit or in turning a motor.

Electric power is the rate at which electrical energy is converted into another form such as mechanical energy, heat, or light.

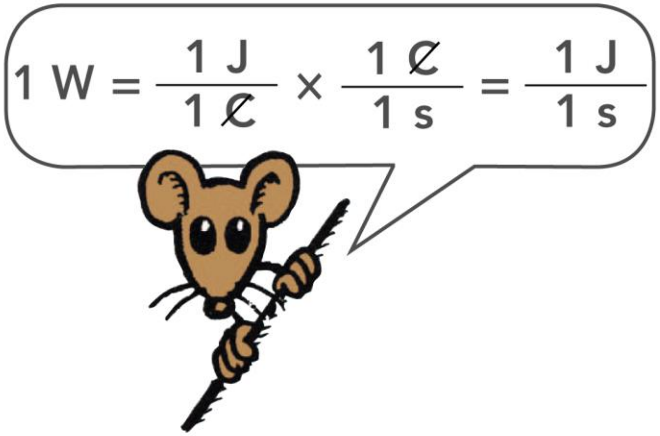
34.11 Electric Power

Electric power is equal to the product of current and voltage.

electric power = current × voltage

If the voltage is expressed in volts and the current in amperes, then the power is expressed in watts.

1 watt = (1 ampere) × (1 volt)



34.11 Electric Power

The power and voltage on the light bulb read “60 W 120 V.”

The current that would flow through the bulb is:

$I = P/V = (60\ \text{W})/(120\ \text{V}) = 0.5\ \text{A}$.

34.11 Electric Power

A lamp rated at 120 watts operated on a 120-volt line will draw a current of 1 ampere:

120 watts = (1 ampere) × (120 volts).

A 60-watt lamp draws 0.5 ampere on a 120-volt line.

34.11 Electric Power

A *kilowatt* is 1000 watts, and a *kilowatt-hour* represents the amount of energy consumed in 1 hour at the rate of 1 kilowatt.

Where electrical energy costs 10 cents per kilowatt-hour, a 100-watt light bulb burns for 10 hours for 10 cents.

A toaster or iron, which draws more current and therefore more power, costs several times as much to operate for the same time.

34.11 Electric Power

think!

How much power is used by a calculator that operates on 8 volts and 0.1 ampere? If it is used for one hour, how much energy does it use?

34.11 Electric Power

think!

How much power is used by a calculator that operates on 8 volts and 0.1 ampere? If it is used for one hour, how much energy does it use?

Answer:

Power = current × voltage = (0.1 A) × (8 V) = 0.8 W.
Energy = power × time = (0.8 W) × (1 h) = 0.8 watt-hour, or 0.0008 kilowatt-hour.

34.11 Electric Power

think!

Will a 1200-watt hair dryer operate on a 120-volt line if the current is limited to 15 amperes by a safety fuse? Can two hair dryers operate on this line?

34.11 Electric Power

think!

Will a 1200-watt hair dryer operate on a 120-volt line if the current is limited to 15 amperes by a safety fuse? Can two hair dryers operate on this line?

Answer:

One 1200-W hair dryer can be operated because the circuit can provide (15 A) × (120 V) = 1800 W. But there is inadequate power to operate two hair dryers of combined power 2400 W. In terms of current, (1200 W)/(120 V) = 10 A; so the hair dryer will operate when connected to the circuit. But two hair dryers will require 20 A and will blow the 15-A fuse.

34.11 Electric Power

CONCEPT CHECK

How can you express electric power in terms of current and voltage?

Assessment Questions

1. Electric charge will flow in an electric circuit when
   a. electrical resistance is low enough.
   b. a potential difference exists.
   c. the circuit is grounded.
   d. electrical devices in the circuit are not defective.

Assessment Questions

1. Electric charge will flow in an electric circuit when
   a. electrical resistance is low enough.
   b. a potential difference exists.
   c. the circuit is grounded.
   d. electrical devices in the circuit are not defective.

Answer: B

Assessment Questions

2. The electric current in a copper wire is normally composed of
   a. electrons.
   b. protons.
   c. ions.
   d. amperes.

Assessment Questions

2. The electric current in a copper wire is normally composed of
   a. electrons.
   b. protons.
   c. ions.
   d. amperes.

Answer: A

Assessment Questions

3. Which statement is correct?
   a. Voltage flows in a circuit.
   b. Charge flows in a circuit.
   c. A battery is the source of electrons in a circuit.
   d. A generator is the source of electrons in a circuit.

Assessment Questions

3. Which statement is correct?
   a. Voltage flows in a circuit.
   b. Charge flows in a circuit.
   c. A battery is the source of electrons in a circuit.
   d. A generator is the source of electrons in a circuit.

Answer: B

Assessment Questions

4. Which of the following type of copper wire would you expect to have the least electric resistance?
   a. a thick long wire
   b. a thick short wire
   c. a thin long wire
   d. a thin short wire

Assessment Questions

4. Which of the following type of copper wire would you expect to have the least electric resistance?
   a. a thick long wire
   b. a thick short wire
   c. a thin long wire
   d. a thin short wire

Answer: D

Assessment Questions

5. When you double the voltage in a simple electric circuit, you double the
   a. current.
   b. resistance.
   c. ohms.
   d. resistors.

Assessment Questions

5. When you double the voltage in a simple electric circuit, you double the
   a. current.
   b. resistance.
   c. ohms.
   d. resistors.

Answer: A

Assessment Questions

6. To receive an electric shock there must be
   a. current in one direction.
   b. moisture in an electrical device being used.
   c. high voltage and low body resistance.
   d. a difference in potential across part or all of your body.

Assessment Questions

6. To receive an electric shock there must be
   a. current in one direction.
   b. moisture in an electrical device being used.
   c. high voltage and low body resistance.
   d. a difference in potential across part or all of your body.

Answer: D

Assessment Questions

7. The difference between DC and AC in electrical circuits is that in DC
   a. charges flow steadily in one direction only.
   b. charges flow in one direction.
   c. charges steadily flow to and fro.
   d. charges flow to and fro.

Assessment Questions

7. The difference between DC and AC in electrical circuits is that in DC
   a. charges flow steadily in one direction only.
   b. charges flow in one direction.
   c. charges steadily flow to and fro.
   d. charges flow to and fro.

Answer: B

Assessment Questions

8. To convert AC to a fairly steady DC, which devices are used?
   a. diodes and batteries
   b. capacitors and diodes
   c. capacitors and batteries
   d. resistors and batteries

Assessment Questions

8. To convert AC to a fairly steady DC, which devices are used?
   a. diodes and batteries
   b. capacitors and diodes
   c. capacitors and batteries
   d. resistors and batteries

Answer: B

Assessment Questions

9. What is it that travels at about the speed of light in an electric circuit?
    a. charges
    b. current
    c. electric field
    d. voltage

Assessment Questions

9. What is it that travels at about the speed of light in an electric circuit?
   a. charges
   b. current
   c. electric field
   d. voltage

Answer: C

Assessment Questions

10. When you buy a water pipe in a hardware store, the water isn't included. When you buy copper wire, electrons
    a. must be supplied by you, just as water must be supplied for a water pipe.
    b. are already in the wire.
    c. may fall out, which is why wires are insulated.
    d. enter it from the electric outlet.

Assessment Questions

10. When you buy a water pipe in a hardware store, the water isn't included. When you buy copper wire, electrons
    a. must be supplied by you, just as water must be supplied for a water pipe.
    b. are already in the wire.
    c. may fall out, which is why wires are insulated.
    d. enter it from the electric outlet.

Answer: B

Assessment Questions

11. If you double both the current and the voltage in a circuit, the power
    a. remains unchanged if resistance remains constant.
    b. halves.
    c. doubles.
    d. quadruples.

Assessment Questions

11. If you double both the current and the voltage in a circuit, the power
    a. remains unchanged if resistance remains constant.
    b. halves.
    c. doubles.
    d. quadruples.

Answer: D