CHAPTER 1

THE BASICS OF ELECTRICITY

LEARNING OBJECTIVES

By the end of this chapter you should know:

- the various tasks that electricity can perform
- how electricity moves
- terms such as volts, ohms, amperes and watts, and their relationship
- the difference between 120 and 240 volts
- what a circuit is
- the functions of fuses and breakers
- the meaning of parallel circuits
- the implications of damaged wire and loose connections

INTRODUCTION

Electricity is an amazing thing. Despite being invisible, it is very versatile. It gives us—

1. Light
2. Heat
3. Mechanical work (electric motors)

Light

Heat

We have learned to control electricity and can make it flow through a very fine wire (filament) in a light bulb, illuminating our rooms. Electricity can heat the water we wash with (a domestic water heater) and the water we use to make coffee (kettles) and cook our food (electric elements on stoves and ovens).

Mechanical

Costs Money and Is Dangerous

Electric motors drive pumps, saws, drills, blenders, lawn mowers, toys, etc. This marvelous invention has been in houses for less than 100 years and has dramatically changed the way we live. The downsides are that it costs money and is dangerous. If we aren't careful with it, it can hurt or kill us, or it can burn down our houses.

1.1 UNDERSTANDING ELECTRICITY

Electrons Move

Electricity is hard to explain because you can't see it. There are several ways you can think of electricity moving through a wire. Here is a crude and simplistic way to look at electricity. In all solid materials, there are tiny electrons moving, although the material seems to be static. Electricity flows when the electrons move in a given pattern. We can move energy along a wire by giving energy to an electron at one end of the wire. The energy moves through the wire and comes out at the other end. One way to think of it is a domino effect. Knocking over the first domino knocks over every domino in the chain.

Ping Pong Balls

Another analogy is a series of Ping Pong balls hanging on individual strings, lined up and touching each other. If you whack the first ball in the row, the last ball at the end of the row will go flying. You've probably seen games that employ this principle with steel balls hanging from strings.

It's Fast

Electricity travels at nearly the speed of light, which is 186,000 miles per second. This means that electricity can travel a mile in about .0000053 seconds. That's quick.

Electrical Charges

Energy is transmitted to electrons with an electrical charge that can be either positive or negative. When we induce a negative charge at one end of a wire, a ripple effect through that wire transfers the electrical charge along its length.

Water Analogy

Some people use a water analogy. Think of the wire as a pipe full of water. If we force more water in one end of the pipe, water will come out the other end (Figure 1.1). A similar analogy is water in a river. If we displace the water at one end of the river, we make a wave. That wave transfers energy along the river, raising the water where the wave is, at any given point.

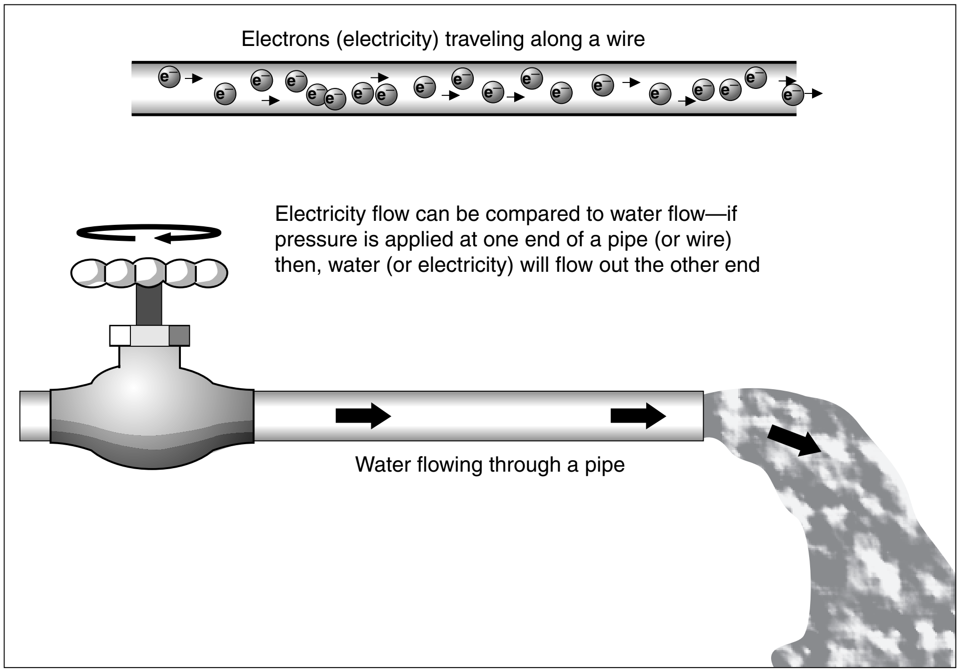
Electricity Flows

Whether or not these analogies appeal to you, you're going to have to trust us. Electricity does flow. We all know from the things we use every day that we can make electricity work for us, lighting and heating our homes, and driving electric motors.

Alternating Current

Alternating current is used in houses instead of **direct current** because we can produce high voltage, efficiently transport it over long distances, and then lower it

FIGURE 1.1 Electricity—Basic Concepts



to safer levels. The electrical pulses in a wire go through 60 cycles every second. This means that the energy traveling through the wire changes direction 120 times per second. You would think that if the electricity keeps changing its mind about which direction it's going, it's not going to get anywhere. However, you have to remember that it only takes .0000053 seconds for electricity to move a mile. Having it change directions 120 times a second is child's play.

1.2 HOW DO WE GET ELECTRICITY WHERE WE WANT IT?

Electricity is somewhat selective about what it can move through. We all know that electricity likes to move through copper wire, for example. It also likes going through aluminum wire, although not quite as well. Electricity really likes going through silver and gold. In fact, it will move through most metals easily.

Conductors

Electricity also moves nicely through tap water, rainwater, and people. Anything that allows electricity to flow through it easily is called a **conductor.** Wires are often called conductors, for good reason. Technically oriented people avoid using the word wire because it's not precise. We will use wire throughout this program, because it's what most people understand easily.

Wires Are Conductors

Insulators

There are many materials that electricity doesn't like to flow through. Air, for example, is one thing that electricity can't flow through very easily. Air is an **insulator.** Other insulators include rubber, glass, ceramics, wood, many plastics and, surprisingly enough, distilled water.

We can control electricity by allowing it to run through **conductors.** We add some safety to it by surrounding the conductors with **insulators.** If we do this correctly, the electricity travels in well-contained spaces.

There are no perfect conductors, nor are there any perfect insulators.

1.3 ELECTRICAL TERMS

Most of the common electrical terms get their names from the people who helped develop the concepts. As we talk about amperes, or amps, volts, ohms and watts, these are all based on people's names. Let's look at what these terms mean.

1.3.1 Volts (Electrical Potential)

Volts or **voltage** is a measure of the force in an electrical system. An average house has 240 volts of electricity available to it. Throughout the house, we can split the 240 volts into separate branches with 120 volts or keep it together with 240 volts of potential.

Voltage Always There

In a house electrical system, the voltage is always available. It will fluctuate slightly. It can drop as low as 210 volts, and rise to about 250. However, for our purposes, we'll think of it as 240 volts.

This force exists even if there's no electricity flowing in the house. Even when everything is at rest, there is this tremendous force in the house waiting to be unleashed. It's one of the reasons electricity is dangerous. If you touch something that doesn't appear to be moving or doing anything, it may have 240 volts or 120 volts looking for a place to go. Since the human body is a good conductor, you provide a very nice way for that force to be released.

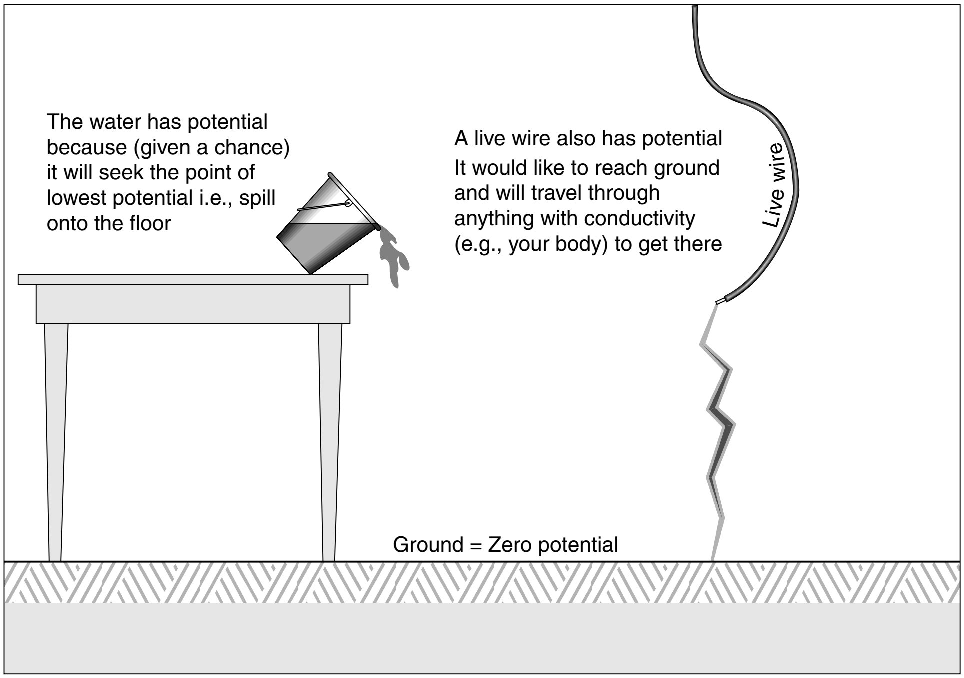
Energy Wants To Be Released

In much the same way that water wants to find the lowest level, areas of high electrical energy wants to flow to areas of low electrical energy.

Ground Has Zero Potential

The ground has zero electrical energy or potential (Figure 1.2). Therefore, everything that has 120 volts or 240 volts stored up in it would love to release all its pent-up energy into the ground. If you happen to be standing on the ground and touch something that has substantial electrical potential energy, you will be the conductor that allows that energy to be released into the ground. This is what hurts or kills people.

FIGURE 1.2 Electrical Potential



Current Must Flow To Hurt You

It's important to understand that the voltage isn't what kills you. Until the electricity starts to flow, there is no energy released and people don't get hurt. For example, if you could hover in mid air and touch something that had 240 volts of energy, you might not feel a thing. That's because air is a good **insulator** and the electricity can't get though you to ground if you're floating in mid air. The air between you and the ground acts as an insulator and no electricity flows. Even though you've touched something with a huge voltage, you might not be adversely affected at all. (As they say on television, "Don't try this at home!")

The symbol for volts can be **V** or **E,** which stands for electromotive force.

1.3.2 Ohms (Electrical Resistance)

Even good conductors don't allow electricity to flow freely. All conductors have some resistance. Insulators have more resistance and don't let much, if any, electricity flow.

Resistance

The resistance of an electrical circuit is measured in **ohms,** and is determined by the size, length, temperature and material that the electricity is trying to flow through. Actually, the total resistance of an AC circuit is called **impedance,** and it includes a couple of other forces that are normally quite small, so we don't need to bother with them.

If the resistance is large enough, no electricity will flow. As the resistance decreases, more electricity will flow. If the resistance is almost nothing, electricity will flow freely.

Resistor

When we put something in a circuit that we want to glow brightly (a light bulb), get warm (a heating element in a toaster), or do some mechanical work (an electrical motor or a drill), each of these appliances is a **resistor.** They are designed to allow a certain amount of electricity to flow. The appliances convert that electrical energy into light, heat or mechanical force (Figure 1.3). In a household circuit, the electrical potential of 120 volts will flow readily through the distribution wiring, but has to fight its way past resistors such as light bulbs.

FIGURE 1.3 Electrical Resistance

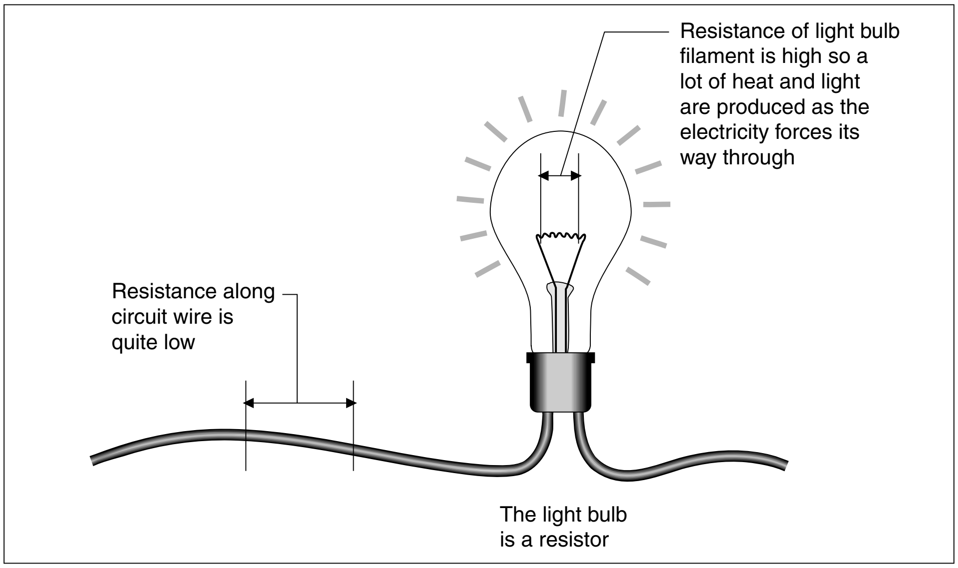
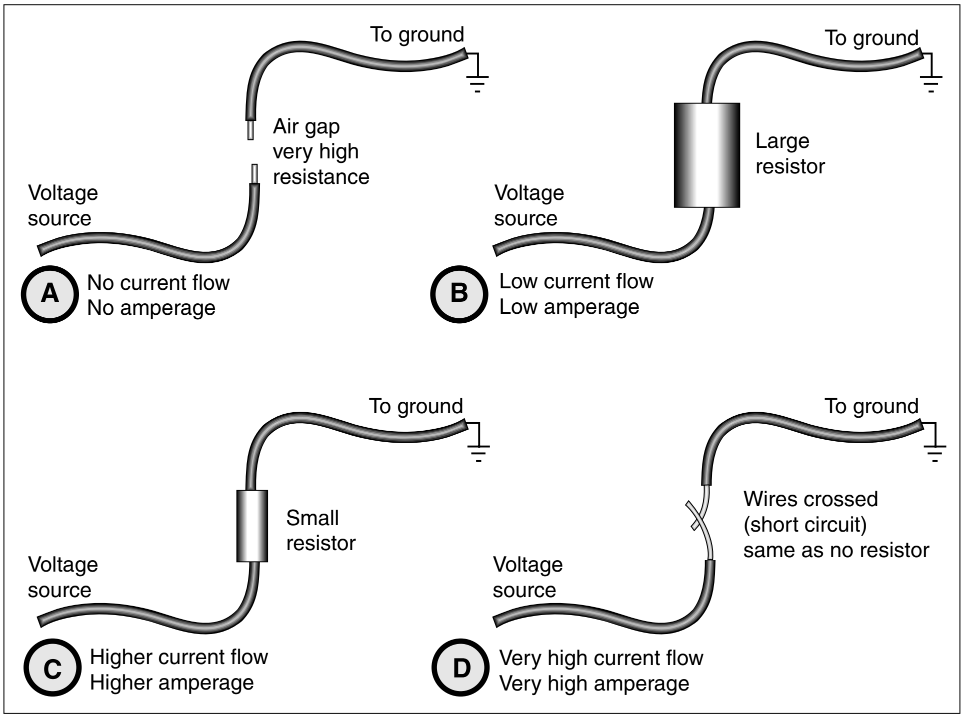


FIGURE 1.4 Current Flow = Amperage



1.3.3 Flow Amperes or Amps (Electrical Current)

Amperes are a measure of how much electricity is flowing through a circuit (Figure 1.4). It's important to understand that **amps** are the result of a fixed **voltage** (force) pushing on a circuit of fixed **resistance.** For electricity to flow, there has to be a path from that source of high potential energy to ground (a point of very low electrical potential). If we have a pressure of 120 volts and a huge resistance, there will be no electrical current flowing and no amps measurable. We call this an **open circuit.**

If the resistance is lowered (for example, by closing a switch), then electricity can flow through the circuit to ground. The amount of resistance that the electricity encounters will determine how much current flows. The larger the resistor, the smaller the flow. The smaller the resistance, the larger the flow.

Short Circuit

If there is no resistor in the circuit, there will be very little resistance and tremendous flow. Electricians talk about this as a **short circuit.** This should blow a fuse or trip a breaker.

Too much electrical flow is a bad thing because wires will overheat and melt. If the resistors are sized appropriately and the current flow is what we wanted, light bulbs will glow, but will not melt, heating elements will give off heat, but not break apart, and electric motors will turn, but not overheat.

1.3.4 Watts (Electrical Energy)

Energy (Power) Consumed

Watts are a measure of the rate of electrical energy being used (consumed or released). The amount of energy depends on the voltage and the resulting current. In fact, to calculate watts, you simply multiply the voltage times the current.

For example, if you had a 120-volt force and a 5-amp current, you would have a 600-watt **rate** of energy consumption.

1000-Watts Is 1 Kilowatt (kW)

When you have 1,000-watts, that's equal to **1 kilowatt (kW).** Five thousand watts equals 5 kilowatts (kW).

1.4 HOW WE PAY FOR ELECTRICITY

A Kilowatt Is a Rate

We pay for the electricity based on the amount we consume. The **amount** we consume is measured by taking the **rate** at which we consume it and keeping track of how long we consume it.

Kilowatt-Hour Is an Amount

We pay for electricity in units called **kilowatt-hours (kWh).** If you use electricity at the rate of 1,000 W for one hour, you will have consumed 1 kilowatt-hour (kWh) of energy. This may cost $0.10 from your electrical utility (the cost varies dramatically depending on where you live).

What a Light Bulb Costs

Remember how your parents used to tell you to turn off the lights? Let's figure out what it costs to leave a 60-watt light bulb on for a week. That 60-watts equals (60/1000) .06 kW, so our rate of consumption is .06 kW. There are 168 hours in a week. We've consumed (.06 × 168) 10.08 kWh by leaving one 60-watt light bulb on for one week.

For a Year

We said that a kWh might cost $0.10. Therefore it costs about $0.10 × 10.08 kWh or $1.00 to leave a 60-watt bulb on for a week. If you left the light bulb on for full year it might cost about $52. Were your parents over-reacting?

On the other hand, if you left all your lights in the house on, that might be 3,000-watts (let's assume 50 light bulbs rated at 60-watts). This is 50 times as much electricity and now the cost for the year is $50 × 50 equals $2,500! Maybe we should turn those lights off.

1.5 THE RELATIONSHIP BETWEEN VOLTS, AMPS, OHMS, AND WATTS

Although we hate formulas, the people who know about electricity have come up with some useful simple formulas:

$V = I \times R$, and

$P = V \times I$.

Where

V = voltage (volts)

I = current (amps)

R = resistance (ohms)

P = power (watts)

We can manipulate these formulas to figure out lots of stuff. For example, if

$V = IR$, then

$I = V/R$ and

$R = V/I$.

In addition, if

$P = VI$, then
$V = P/I$, and
$I = P/V$.

If you know any two of P, V, R, or I you can find the other two with these two formulas.

For a household circuit, V is always either 120 volts or 240 volts.
Examples:

1. How much current does a 1,200-watt hair dryer draw?

- $P = 1200$-watts
- $V = 120$ volts
- $P = V \times I$, so
- $I = P/V$
- $I = 1200/120 = 10$ amps.
- The hair dryer draws 10 amps.

2. How much current does a 4.8 kW clothes dryer draw?

- $P = 4.8$ kW $= 4800$ watts
- $V = 240$ volts
- $P = V \times I$, so
- $I = P/V$
- $I = 4800/240 = 20$ amps.
- The clothes dryer draws 20 amps.

1.6 MORE ON THE WATER ANALOGY

Water Pressure Is Like Voltage

Think of voltage as water pressure. Water pressure in a pipe is usually measured in psi (pounds per square inch). This pressure usually comes from either a pump or a gravity tank. Water coming into your house is under pressure. It may be anything from 20 to 80 psi. When the water is not flowing, the pressure is always there, ready to spurt out as soon as you open the tap. This is the same as the voltage in the house; it's always there, ready to flow as soon as we close the circuit.

Switches Are Like Valves

When the water isn't flowing, the pressure (psi) is the same all along the pipe. When electricity isn't flowing, the pressure (voltage) is the same all along the length of the wire. A closed valve on the piping system stops the water flow. An open switch in an electrical circuit stops all electrical flow. You can think of switches in electrical systems as valves in water piping systems. Closing the switch results in current flow. Opening the valve results in water flow.

Resistance Is Like Friction

The resistance of an electrical circuit is similar to the resistance created by the pipe walls when water is flowing. With electricity, the greater the resistance, the smaller the rate of electrical current flow will be. Similarly, with water, the greater the resistance in the pipe (because of a small pipe diameter, or a rough surface on the interior of the pipe walls), the smaller the rate of water flow.

Amps Are Like Gallons Per Minute

The electrical current or flow, measured in amps, is similar to the water flow measured in gallons per minute (or liters per second, for those metrically inclined).

In the electrical situation, we've said that the flow results from applying a fixed pressure across a given resistance. Similarly, if we have a fixed water pressure pushing through a piping system with a fixed resistance, we will have a resultant flow measured in gallons per minute.

1.7 IS IT 120 OR 240 VOLTS?

120 Volts in Black Wire

120 Volts in Red Wire

Houses have 240 volts available, and yet most of the household circuits are 120 volts. Let's look first at how we get 120 volts and 240 volts. Electricity comes into houses through two **hot** wires. By convention, one is called **black** and one is called **red,** although in real life, both are often black. We also bring in a **neutral** wire but it doesn't carry any electricity into the house. It is a path back to ground through the transformer at the street (Figure 1.5).

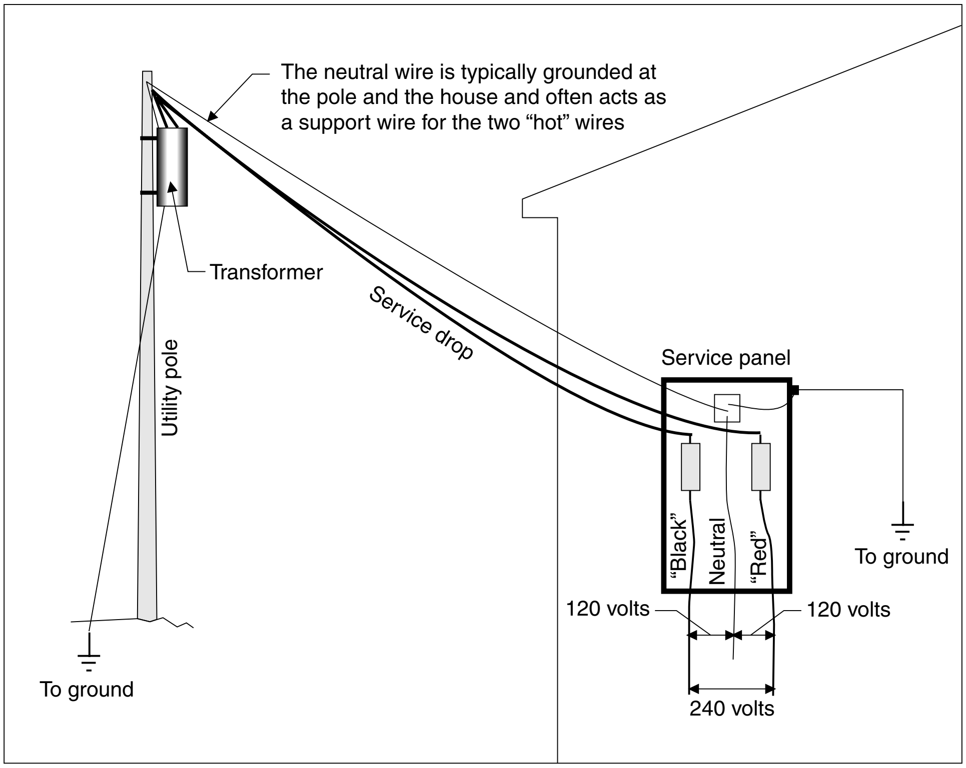
120-Volt Circuits

Both of the two hot wires carries 120 volts. A circuit from the black wire to the white creates a pressure of 120 volts. A circuit from the red wire to the white also creates a pressure of 120 volts.

240-Volt Circuits

We can create a pressure of 240 volts by making a circuit between the black and the red wires. Although each of these is 120 volts, the black wire electricity is 180° out of sync with the red wire electricity. We are dealing with alternating current here. A simplistic (and incorrect) way to think of this is to say that the electricity pulses, rests and then pulses in the reverse direction. You can think of the electrical current flowing through the **black** wire to white as going—

FIGURE 1.5 120/240 volts



1. Pulse
2. Rest
3. Pulse
4. Rest, etc.

You can think of the electricity flowing through the **red** wire to the white in the same way but shifted so it will be going—

1. Rest
2. Pulse
3. Rest
4. Pulse, etc.

Each of these is a 120-volt circuit. Creating a circuit between black and red wires generates a greater electrical pressure (240 volts worth) and when the electricity flows, it can be thought of as—

1. Pulse
2. Pulse
3. Pulse
4. Pulse, etc.

No Neutral Needed

When the black wire pulses, the red wire acts like a white wire. When the red wire pulses, the black wire acts like a white wire. We don't need a neutral wire in a balanced 240-volt circuit!

With apologies to electricians, this is one way to think of how the red and black wires combine to provide 240 volts. We didn't even need a white wire! We'll talk about this more a little later.

1.8 WHICH IS BETTER, 120 VOLTS OR 240 VOLTS?

It depends on what we are trying to do. For most household circuits, 120 volts is just fine. Most small household appliances are designed to run on 120 volts.

240 Volts

Large appliances, such as stoves, water heaters and central air conditioners, usually run on 240 volts. The larger pressure allows us to do more electrical work without large current flows. Although we could design these appliances to run on 120 volts, we'd have to use very large wires to safely carry the large currents. That's expensive and inefficient.

It boils down to what is most practical. In North America we use the 120/240-volt system. In Great Britain, for example, they use a 240-volt system. Even their small appliances are designed to run on 240 volts, and all the circuits in their houses are wired for 240 volts.

1.9 COLOR CONVENTIONS

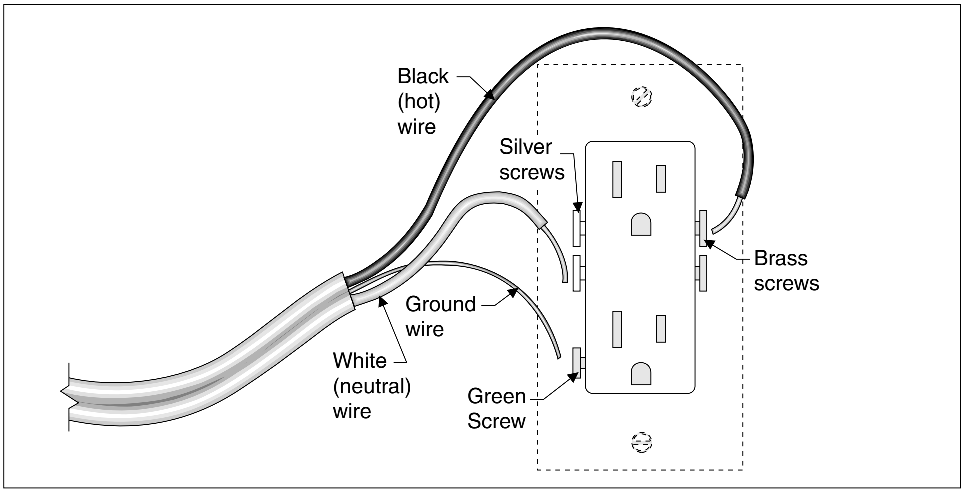
Red Is Often Black

We've already said that both the black and the red wires are hot (ungrounded). We've also said that the red wire isn't always red. Sometimes it's black.

White Can Be Black

The white wire (which is sometimes gray) is the neutral (grounded) wire. Again. this is a convention and there are exceptions where the white wire acts as black. Hey,

FIGURE 1.6 Color Coding for Typical 120 Volt Circuit



if it were simple, anyone could figure it out! When electricians use the white wire as a black they are supposed to tape or otherwise color the ends of the wire black, so people working on the system know it's a hot wire. It doesn't always get done.

Green Is Ground but It's Really Bare

The bare wire is the equipment ground (grounding) wire. The convention for it is green. There's usually no sheathing on it, but in some cases terminal screws for the ground wires are color-coded green.

Black to Brass White to Silver

Incidentally, color coding on outlets and switches for black or red wires is **brass** and for white wires is **silver** (Figure 1.6). The heads of the screws on a switch or outlet are actually brass colored or silver colored to tell you where the wires should go.

1.10 WHAT IS A CIRCUIT?

Black to Resistor

White to Ground

Electricity flows from an area of high energy to an area of low energy. The high energy area is the black or red wire. The low energy area is ground. Most electrical circuits are set up with a black wire going out through some kind of control (a switch, for example), through a resistor, and back through the neutral wire to ground.

Switch off (Open)

When the switch is off (or open) the circuit is said to be **open** (Figure 1.7). There will be no electricity flowing, and there will be 120 volts in the circuit from the power supply through the black wire up to the switch only. Because the switch is off, there will be no voltage from the switch through the rest of the circuit.

Switch on (Closed)

Electricity Flows

When the switch is turned on (closed), the circuit will be activated. This is referred to as a **closed circuit** and electricity will flow through the circuit. The appliance (resistor) will light up, give off heat, or do work, depending on what it is. Electricity will be flowing through every point in the wire. It's just like water flowing through a pipe. When there's water coming out of the faucet at the end, there is water flowing past every point in the pipe. No matter where you measure the current flow (amperage) in the circuit, you get the same reading.

Short Circuit

A **short circuit** is a malfunctioning circuit (Figure 1.8). If the circuit described in the previous paragraph had a light bulb as the resistor, we could create a short circuit by taking out the light bulb and filling the light bulb socket with coins.

FIGURE 1.7 A Simple Electrical Circuit

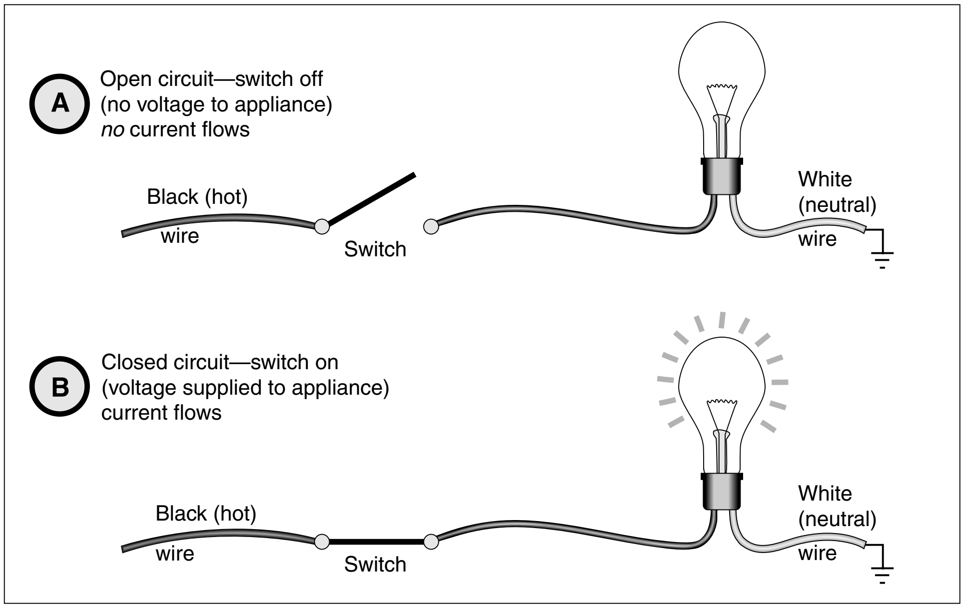
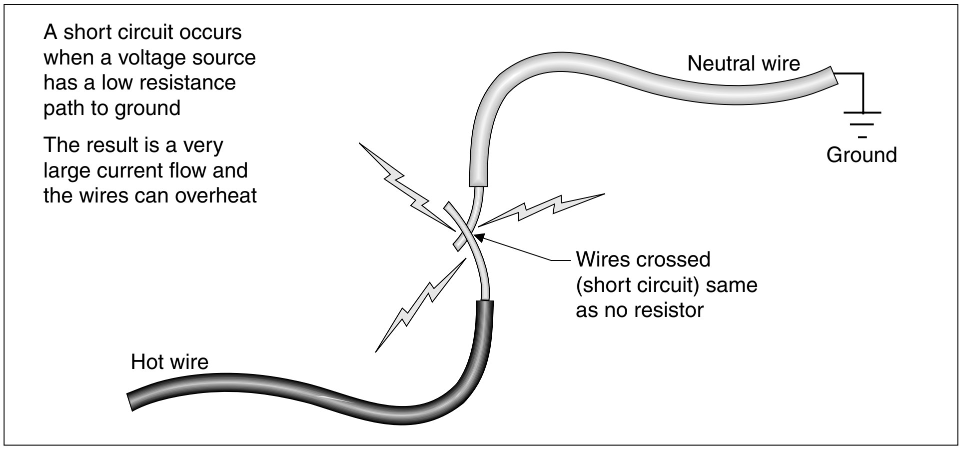


FIGURE 1.8 Short Circuit



This creates a circuit that has a power source and a path to ground, but very little resistance. The coins in the socket act as a piece of wire.

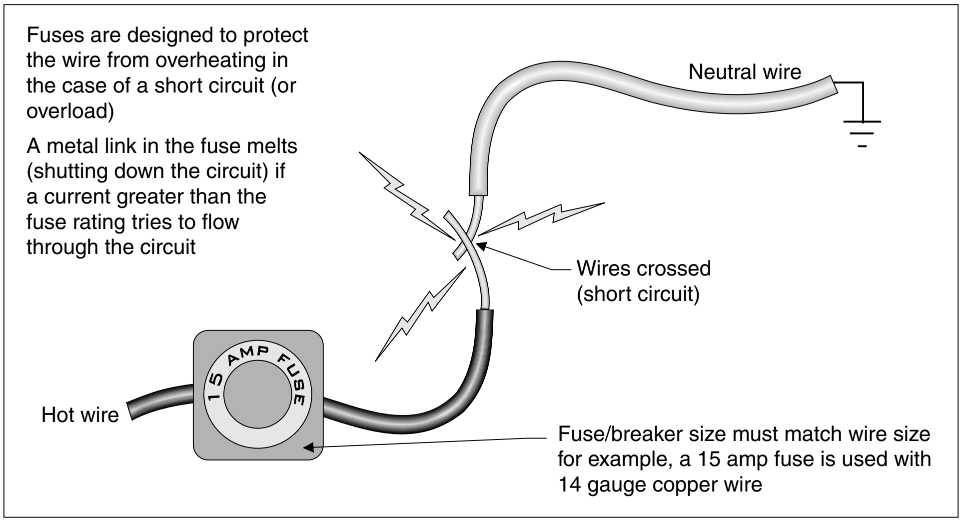
Wire has very little resistance. Putting 120 volts across a very small resistor leads to a very large current. This is a short circuit. There would be a large current flowing through this circuit and the wires would overheat.

1.11 FUSES OR BREAKERS

Fuses Are the Brains

These **over current protection devices** are needed because wire is stupid. You can think of the fuses or breakers as the brains of the circuit. The wire isn't smart enough to control how much electricity flows through it. Wire will allow electricity to flow and heat up the wire to the point where the wire will melt and possibly start a fire.

FIGURE 1.9 Fuses and Breakers



Fuses Protect Wires

This is why we need fuses and breakers. The fuses and breakers are an integral part of the circuit (Figure 1.9). They're at the beginning of the circuit, close to the power source. If too much current flows, the fuse or breaker will shut off the electrical flow and protect the wire from overheating.

Fuse Size Must Match Wire Size

Once you understand the job of a fuse or breaker, it's easy to understand why it's important to have the right size fuse or breaker on the wire. Since you can get different sizes of wire, you also have to buy fuses or breakers that are different sizes. If the fuse is too large for the wire, it won't shut the electricity off soon enough, and the wire may overheat. This is unsafe. If the fuse is too small for the wire, the fuse will blow and shut off the circuit even though the wire is capable of carrying more electricity. This is frustrating.

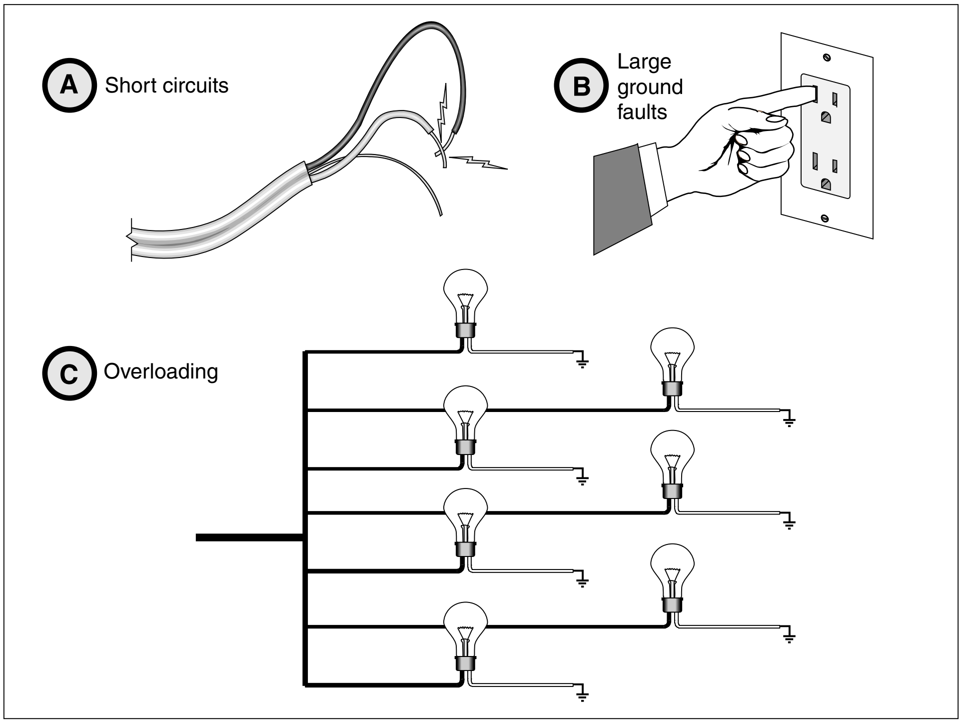
Fuses or breakers should shut off power when too much current flows. Circuits may carry too much current because of short circuits or overloads (Figure 1.10). There are three common types of short circuits.

Short Circuits

1. If there is a short circuit, the resistor will be bypassed. This occurs when you replace the light bulb with coins in the socket.
2. Another type of **short circuit** is caused when a nail is driven into the cable, bridging the black and white wires. The electricity flows out through the black wire, through the nail and back through the white wire without going through a resistor.
3. A **ground fault** is another type of short circuit. A person, for example, touches a black wire and creates a very nice path to ground through their body. The electricity flows from the power source to the black wire, but then goes through the person directly to ground, rather than through the white wire back to ground. This ground fault situation is obviously a very dangerous one. A fuse or breaker may not shut things down quickly enough to save someone's life. If the circuit is less than 15 amps, the fuse or breaker won't react at all.

   A black wire that comes loose and touches the earth (ground) directly is another example of a ground fault.

FIGURE 1.10 Fuses Provide Protection Against Several Situations



Overload

4. An **overload** typically occurs on a circuit with several electrical receptacles or outlets. If people plug too many appliances into outlets on one circuit, the current flow will be more than the wire can safely carry.

Fuses Are Like Breakers

Fuses and breakers help protect the wire and people from these electrical problems. The main difference between a fuse and a breaker is that a breaker can be reset, while a fuse has to be replaced. This makes breakers more convenient. However, some electricians feel that breakers are not necessarily better than fuses because, like any mechanical device, they can fail to trip.

Fuses and Breakers Don't Save People

Fuses and conventional breakers will not prevent a person from receiving a fatal shock. They are not primarily safety devices with respect to electrical shock.

1.12 PARALLEL AND SERIES CIRCUITS

Series Circuits

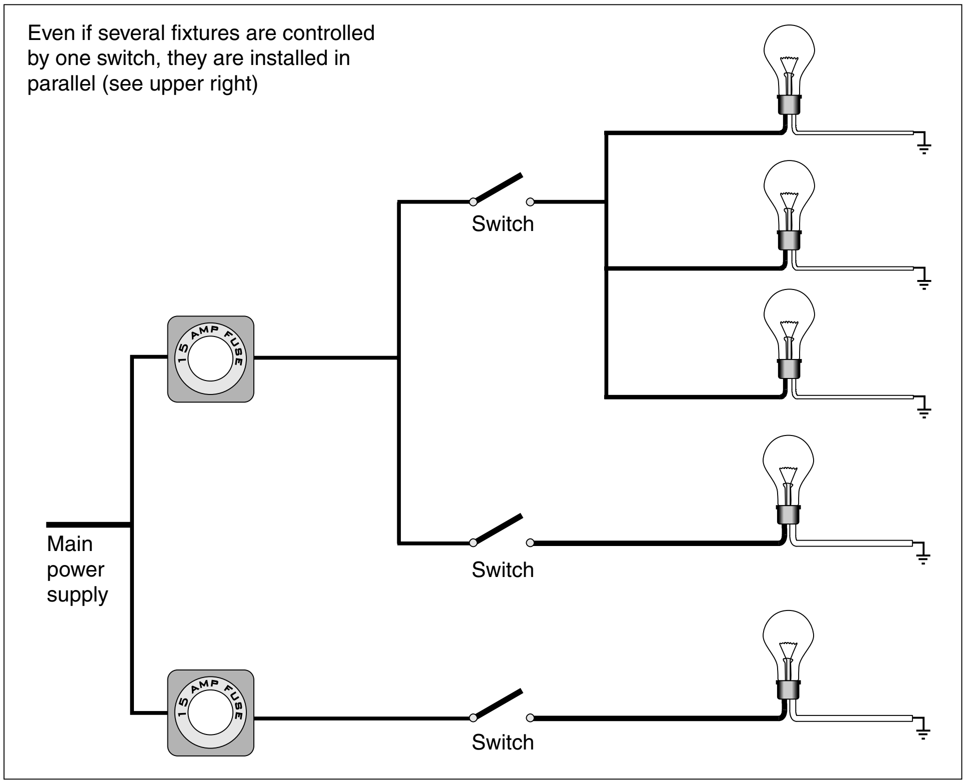
Houses are generally wired in **parallel** rather than **series** circuits for a couple of reasons (Figure 1.11). Think of the series circuits on old Christmas tree lights. If one light bulb doesn't work, none of the lights will come on, because all the electricity has to flow through each light bulb in sequence. A broken filament in one bulb creates an **open circuit** and the electricity can't flow.

All Current Flows Through Every Bulb

More Bulbs Make Other Bulbs Dim

Another problem with series wiring is, as we extend the circuit, by adding more lights; each light we add makes the other lights dimmer. That's because we're increasing the total linear resistance in the circuit. The voltage is fixed, so as the resistance increases, the current flow must decrease.

FIGURE 1.11 Household Wiring Is Done in Parallel



Parallel

Neither of these are desirable situations, therefore, our houses are wired in **parallel.** Electricity has several paths it can follow from the energy source to ground. Even with several light fixtures controlled by one switch, the light fixtures are in parallel. If one light bulb burns out, electricity still flows through the other bulbs.

More Bulbs Don't Make Others Dim

The other feature of parallel circuits is that adding another light or resistor of any kind will not cause the others that are already working to get dimmer or draw less current. If you think of a simple circuit with a 60-watt light bulb and a 120-volt power supply, the resultant current will be $^1/_2$ amp (I = P/V = 60/120 = 1/2). Any place in this circuit where we measure the current, we have $^1/_2$ amp flowing.

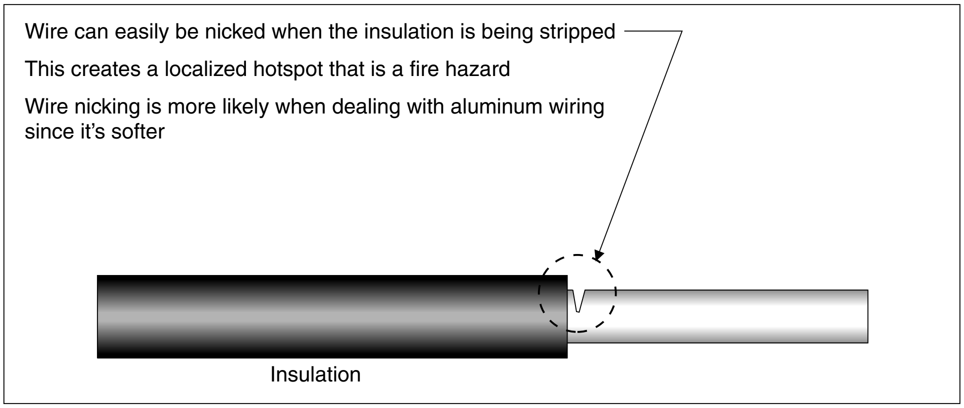
If we add a second 60-watt light bulb in parallel, the circuit has a second branch. In each leg of the branch, the current flow would be $^1/_2$ amp. Before the branch splits, and after it comes back together, the current would be 1 amp. However, when the second light is added, the first light still sees the $^1/_2$ amp current flow and does not change in brightness.

If this seems like magic to you, you'll just have to accept that this is the way electricity works. Incidentally, you can extend this picture. If you put a third branch in with another 60-watt light bulb, it too, would draw $^1/_2$ amp, and the total current draw in the common parts of the circuit would be $1^1/_2$ amps. There are three **parallel** paths, each carrying $^1/_2$ amp.

Overload

You can see that if you put in thirty 60-watt light bulbs, you are going to draw 15-amps (I = P/V = 30 × 60/120 = 15). Fifteen amps flowing through a conventional household wire is close to the point where you'll blow the fuse or trip

FIGURE 1.12 Damaged Wire



the breaker. This is the threshold of an **overload** situation. A general design limitation is to restrict a 15-amp circuit to 80 percent of its rated capacity. This limits the circuit to 12 amps, maximum.

1.13 DAMAGED WIRE

Crimped Pipe

In some ways, you can think of a damaged wire the same way you think of a crimped pipe in a water analogy. If a pipe is crimped, it won't let as much water flow past the pipe at that point. That will reduce the total flow.

Nicked Wire Overheats

A bottleneck is also created where a wire has been nicked, since part of the wire is removed (Figure 1.12). Unfortunately, electrical wire is not as smart as water pipe. Rather than restrict the electrical flow, it will (within limits) allow the electricity to flow but create a point of high heat where the wire has been nicked. This can be dangerous. If the wire heats up too much, a fire could start.

Fuse Won't Blow

The fuse or breaker probably won't save us, since the overall circuit is working normally and the flow through the circuit may only be 10 amps. This would not blow a 15-amp fuse. The 10 amps, which is perfectly safe flowing through a full sized wire, can overheat the wire where a chunk has been removed.

1.14 LOOSE ELECTRICAL CONNECTIONS

Bottleneck Causes Overheating

A loose connection is similar to a damaged wire. When two wires are joined together, the contact area should not restrict the electrical flow. If the connection is made well, electricity can flow through from one wire to the other freely. However, if the connection is not well made, the wires may be barely touching. This creates a bottleneck again, and a possible overheating situation.

Loose connections may occur anywhere a wire is connected to another wire, a fixture, a switch, an outlet, or any terminal. Loose connections can be thought of as damaged wires in the sense that normally safe electrical currents create overheating situations.

As we move to the systems in the house, we will be using these principles. Please make sure you understand these before moving on. You may want to review this material.

CHAPTER REVIEW QUESTIONS

Answer the following questions on a separate sheet of paper, then check your results against the answers provided in Appendix F. If you have trouble with a question, refer back to the chapter to review the relevant material.

1. Electricity can perform three very different tasks. What are they?
2. Electrical wiring in a house is direct current.
   True False
3. Which of the following are good conductors? (Choose three).
   - **a.** Copper
   - **b.** Plastic
   - **c.** Rubber
   - **d.** Aluminum
   - **e.** Wood
   - **f.** Concrete
   - **g.** Silver
4. Which of the following are good insulators? (Choose three).
   - **a.** Gold
   - **b.** Glass
   - **c.** Ceramics
   - **d.** Steel
   - **e.** Air
   - **f.** Tap water
5. Give a brief definition of a volt.
6. Give a brief definition of an ohm.
7. Give a brief definition of an amp.
8. Give a brief definition of a watt.
9. If electricity costs $ .10 per kilowatt-hour, how much does it costs to leave a 60-watt light bulb on for a year? (Round to the nearest dollar).
10. Give two formulas that describe the relationships between volts, amps, ohms, and watts.
11. A 120-volt circuit uses a black and red wire.
    True False
12. Larger appliances usually require 240 volts.
    True False
13. When the switch is turned off, is the circuit open or closed?
    Open Closed
14. The wires should be considered the brains of the circuit.
    True False
15. The size of the fuse should be
    - **a.** larger than the rating of the wire
    - **b.** the same as or smaller than the rating of the wire
    - **c.** the same as the panel rating
    - **d.** based on the total load of the circuit
    - **e.** the same as the wire rating for 120-volt circuit and twice the rating of the wire for a 240-volt circuit
16. Turning on another light bulb in the same circuit should not dim the bulbs that are already on because ______.

17. A wire that is nicked is likely to ______ when carrying normal current loads.

18. A loose connection is likely to ______ when carrying normal current loads.

KEY TERMS

electrons
alternating current
conductors
insulators
volts
amps
kilowatt-hours
120/240-volt
circuit
fuses
breakers
short circuit
ground fault
overload
parallel
damaged wire
loose connections
overheat