Student Guide

For

Electronic Snap Circuits®

Model SC-100R

Hands-on Program for Basic Electricity and Electronics

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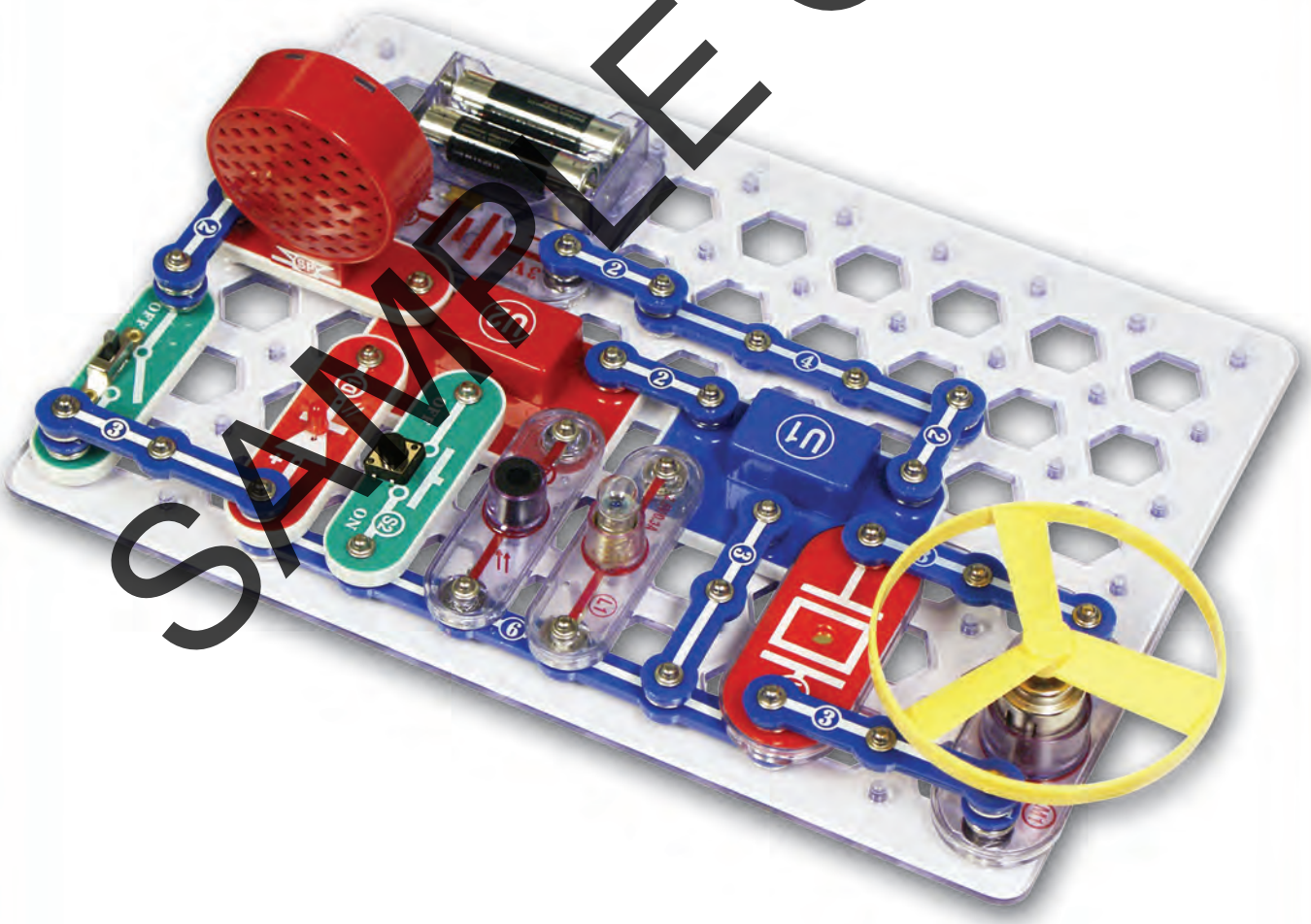
Wheeling, IL 60090 U.S.A.



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THE SNAP CIRCUITS® PROJECT MANUALS

The Snap Circuits® project manual includes lots of useful information in addition to the projects themselves, as listed below. The project manual summarizes much of the lesson in the Student Guide while adding troubleshooting information.

Much of the text in all chapters is color-coded green and blue so that instructors can easily adapt the course based on the skills and interests of the students. The orange boxes are more advanced material while the brown boxes are considered additional/background material, either can generally be omitted without a significant impact on the course.

The Project Manual contains:

1. Parts List (partial, continued in second manual)
2. **How To Use It** - brief description of how to make connections and understand the circuit drawings.
3. **About Your Snap Circuits® Parts** - brief description of what each component does (partial, continued in second manual).
4. **DO's and DON'Ts of Building Circuits** - brief but important guidelines for building circuits (additional guidelines are in second manual).
5. **Basic & Advanced Troubleshooting** - systematic testing procedure for identifying damaged parts (continued in second manual).
6. Project Listing
7. Projects 1-101

Preface

This booklet is an introduction to the exciting world of electronics. Following the "Learn by Doing®" concept, electronics will be easy to understand by using Snap Circuits® to actually build circuits as you learn about them. This booklet emphasizes the practical applications of electronics, without bogging down in mathematics.

Why learn about electronics? Electronics plays an important and increasing role in our everyday lives, and so some basic knowledge of it is good for everyone. Learning about it teaches how to do scientific investigation, and the projects develop basic skills needed in today's world.

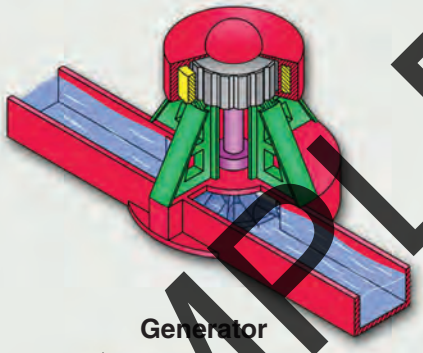
The first pages of the Snap Circuits® project manuals contain a brief description of the parts in Snap Circuits®, along with brief guidelines for building circuits.

CHAPTER 1: BASIC COMPONENTS & CIRCUITS

Learn By Doing®

What is electricity? Nobody really knows. We only know how to produce it, understand its properties, and how to control it. It can be created by chemistry (batteries), magnetism (generators), light (solar cells), friction (rubbing a sweater), and pressure (piezoelectric crystals).

Batteries



Generator

Solar Cells

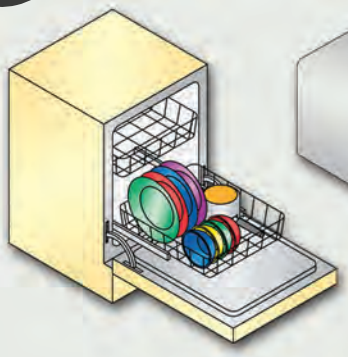
Rubbing a Sweater

Piezoelectric Crystal

In this section you will learn about basic electrical components and circuits. By building circuits using Snap Circuits®, you will begin to understand the electrical world.

Electricity is energy that can be used to save us effort (electric toothbrushes and dishwashers), heat things (electric heaters and microwave ovens), make light (light bulbs), and send information (radio and television). But electricity can also be dangerous if abused (electric shock).

Electric Toothbrush

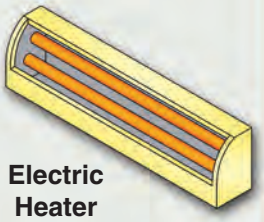


Dishwasher

Microwave Oven

Light Bulb

Radio



Electric Heater

Television

Electric Shock

Quick Quiz

1. Draw a schematic for a circuit that consists of three lamps powered by a battery.
2. For each room in your home, make a schematic drawing showing how the lamps and switches controlling them are connected together.

Summary

Summary of Chapter 1:

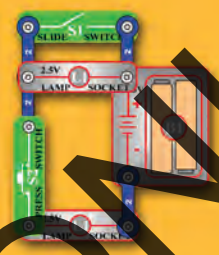
1. The electric current is a measure of how much electricity is flowing in a wire, and is expressed in Amperes.
2. The voltage is a measure of the electric pressure exerted into a wire or circuit by a battery or other power source, and is expressed in volts.
3. Switches are used to turn on or turn off the flow of electricity in a circuit.
4. A light bulb converts electricity into light.
5. Most electronic products have components mounted on circuit boards with the wires literally printed on the board surface.
6. Electrical circuits are all combinations of series and parallel configurations.
7. A short circuit is a no-resistance path across a power source, and causes damage to components and batteries.
8. Solder is a special metal that is melted to make solid electrical connections.
9. Schematics are engineering drawings of circuits using symbols.

Quiz

Chapter 1 Practice Problems

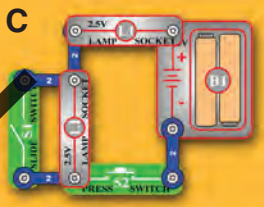
1. The flow of electricity is measured in _____.
   A. gallons B. minutes C. amperes D. volts
2. To turn on a switch, you _____ it.
   A. voltage B. open C. pressurize D. close
3. Three of the choices below are the same circuit with the parts arranged in different ways. Which choice is a different circuit?

A



B

C



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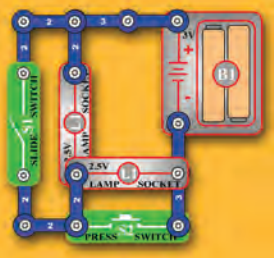
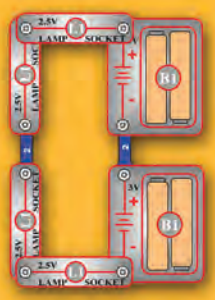


4. Which of these is a short circuit?

A



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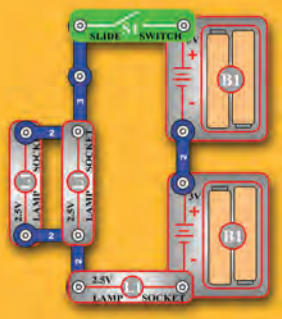
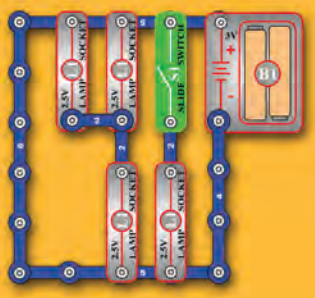
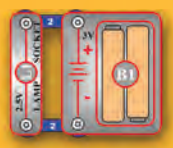


C



D



Answers: 1. C, 2. D, 3. D, 4. C

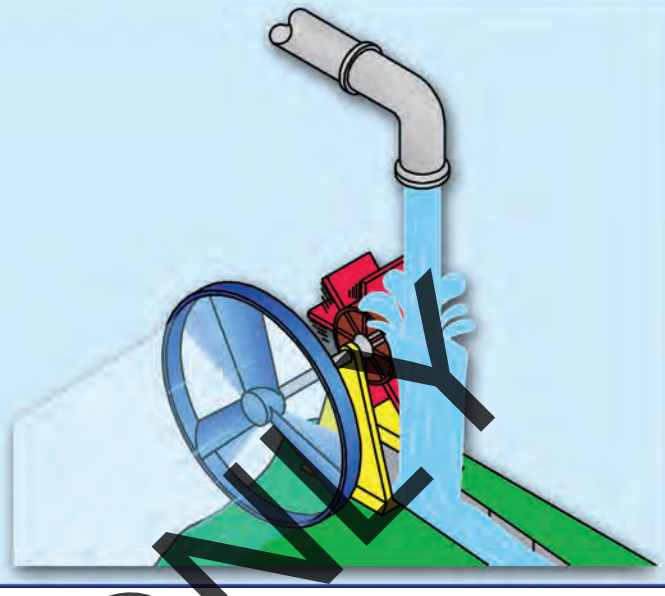
In this chapter you will learn about generators and motors. A generator uses mechanical motion to create electricity and a motor uses electricity to create mechanical motion. This statement may not seem important to you but it is actually the foundation of our present society. Nearly all of the electricity used in our world is produced at enormous generators driven by steam or water pressure. Wires are used to efficiently transport this energy to homes and businesses where it is used. Motors convert the electricity back into mechanical form to drive machinery and appliances. **The most important aspect of electricity in our society** - more important than the benefits of the Internet - **is that it allows energy to be easily transported over distances**.

Note that "distances" includes not just large distances but also tiny distances. Try to imagine a plumbing structure of the same complexity as the circuitry inside a portable radio - it would have to be large because we can't make water pipes so small. Electricity allows complex designs to be made very small.

2-1 Motors

Water flowing under pressure in a pipe or a fast-moving stream can be used to turn a paddlewheel. If the paddlewheel was linked to a fan blade then you could use the water pressure to turn the fan, perhaps to cool yourself on a hot day. If the water was flowing very fast due to high pressure, then you could get the fan moving fast enough it might create a strong airflow like a propeller on a plane.

A similar thing happens in a motor, with electricity instead of water. A motor converts electricity into mechanical motion.



Introducing New Parts

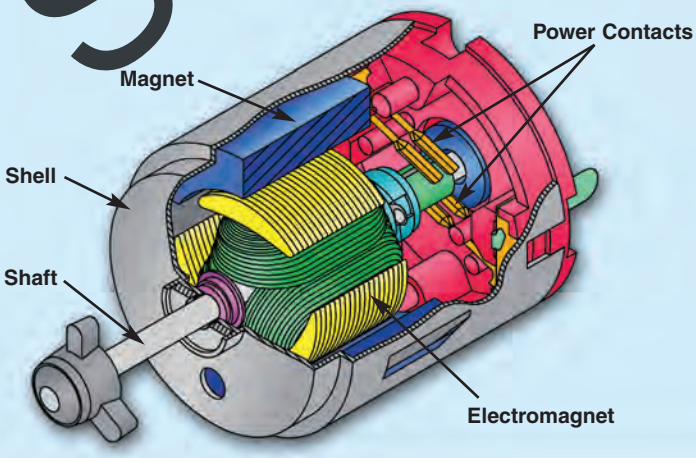
Snap Circuits® includes one motor, shown here with its symbol. Snap Circuits® also includes a fan, which is used with the motor. An electric current in the motor will turn the shaft and the motor blades, and the fan blade if it is on the motor.

Motor Symbol

Motor (M1)

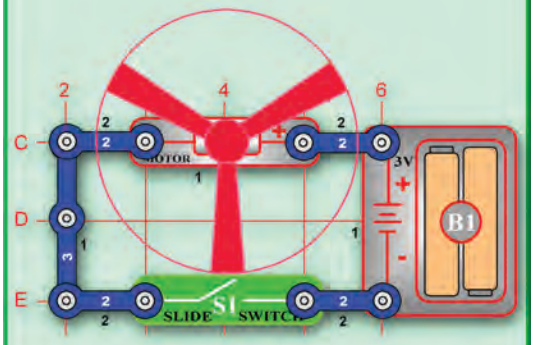
Fan Blade

How does electricity turn the shaft in the motor? The answer is magnetism. Electricity is closely related to magnetism, and an electric current flowing in a wire has a magnetic field similar to that of a very, very tiny magnet. Inside the motor is a coil of wire with many loops wrapped around metal plates. This is called an electromagnet. If a large electric current flows through the loops, it will turn ordinary metal into a magnet. The motor shell also has a magnet on it. When electricity flows through the electromagnet, it repells from the magnet on the motor shell and the shaft spins. If the fan is on the motor shaft then its blades will create airflow.



Experiments

Consider this circuit (which is project 2):

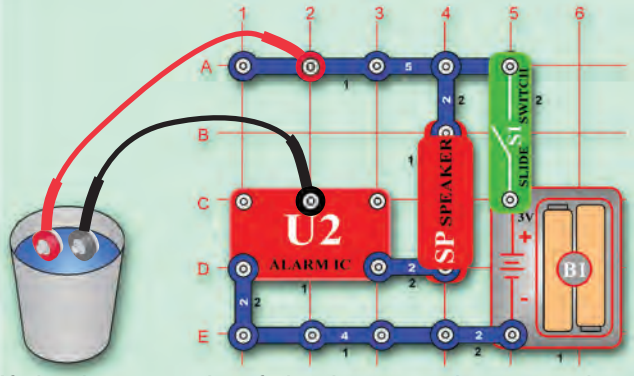


When the switch is on, current flows from the batteries through the motor making it spin. The fan blades will force air to move past the motor. Be careful not to touch the motor or fan when it is spinning at high speed.

3-6 Resistance of Water

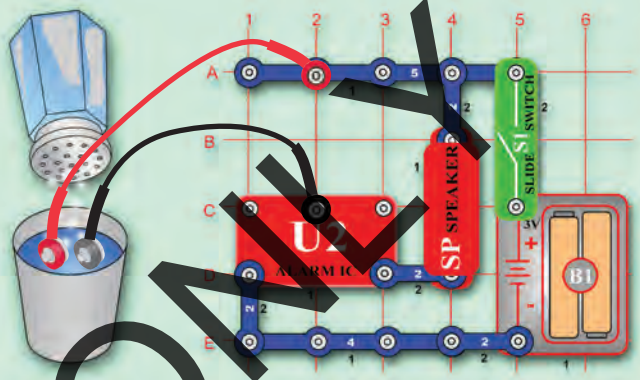
Experiments

Consider this circuit (which is project 98):



If the loose ends of the jumper wires are placed into a cup of water, an alarm will sound. The circuit can be used as a water detector. The tone depends on your local water supply. If more water were added to the cup, the tone would change slightly. Note that this circuit uses the alarm IC (U2) and the speaker (SP), which you will learn about in chapter 4.

Pure water (like distilled water) has very high resistance, but drinking water has impurities mixed in that lower the resistance. What would happen if salt was added to the cup and dissolved in the water?



Dissolving salt in water decreases the resistance of the water, so the tone of the alarm is louder and faster. It could be used as a salt-water detector.

4-4 Integrated Circuit Projects

Integrated circuits are used in most electronic products; there are probably more than a thousand throughout your home. The range and uses of ICs available is hard to imagine.

Although Snap Circuits® contains only five IC modules, more than half of the projects use at least one. There are many more examples of using the parts described in the preceding chapters, such as the whistle chip and photoresistor. Here is a short description of each, the project manuals explain them in more detail:

Suggested Projects: 38, 51, 58, 61, 81, and 83.

Project 3: Uses the music IC with the whistle chip as a vibration sensor.

Project 4: Uses the music IC with the whistle chip as a vibration sensor.

Project 10: Combines the sound effects of the music and space war ICs.

Project 15: Uses the music IC as a doorbell.

Project 16: Uses the music IC as an alarm.

Project 17: Makes one of the alarm IC siren sounds.

Project 18: Makes one of the alarm IC siren sounds.

Project 19: This is the standard circuit using the space war IC.

Projects 20-21: This uses the photoresistor with the space war IC.

Projects 22-26: Uses the photoresistor and music IC to control the alarm IC siren sounds.

Projects 27-31: Uses the whistle chip and music IC to control the alarm IC siren sounds.

Projects 32-33: Uses the whistle chip and music IC to control the space war IC.

Projects 34-35: Uses the motor and music IC to control the space war IC.

Projects 36-37: Uses the motor and alarm IC to control the space war IC.

Projects 38-39: Uses the alarm IC to control the music IC. An example of a periodic (repeating) signal.

Projects 40-44: Uses the motor and music IC to control the alarm IC siren sounds.

Project 45: Uses the photoresistor, music IC, and alarm IC to control an LED.

Project 46: Makes one of the alarm IC siren sounds.

Project 51: The alarm IC uses the photoresistor to sense reflections from a lamp.

Project 52: The alarm IC uses the photoresistor to sense reflections from a lamp.

Project 53: Sound and light controlled by the alarm IC.

Project 54: Uses the alarm IC to control the space war IC.

Project 58: Uses the music IC to control the alarm IC, with additional control from the whistle chip and photoresistor. Also shows how some parts can be used as wires.

Project 60: Uses the alarm and space war ICs to control the motor.

Projects 61-65: The alarm IC makes sound with the whistle chip; loudness is controlled by the photoresistor.

Project 66: Uses the space war IC in a mind-reading game.

Project 67: Uses the space war IC in a mind-reading game.

Project 68:	Combines the sound effects of the music and space war ICs.
Project 69:	Combines the sound effects of the alarm and space war ICs.
Project 70:	Uses the alarm IC as a water detector.
Projects 71-76:	Use either the photoresistor, whistle chip, or motor to control a light using the music IC.
Project 77:	Uses the alarm and space war ICs to control a light.
Project 78:	Makes an AND gate with the music IC.
Project 79:	Combines effects from the music and alarm ICs.
Projects 81-82:	Allows you to DRAW an activator for the alarm IC.
Project 83:	Effects from the music and alarm ICs are combined in several different ways.
Projects 84-85:	Sound effects from the music and alarm ICs are combined with the motor (in most manuals).
Project 86:	Effects from the music and alarm ICs are combined in several different ways.
Project 87:	Makes a fun sound with the space war IC.
Project 88:	Makes fun sounds by controlling the space war IC with the motor.
Projects 89-91:	The photoresistor and whistle chip are used to control the space war IC.
Projects 92-97:	Uses water to control the space war IC in various ways.
Projects 98-101:	Uses the alarm IC to make a water alarm in several ways.

Summary

Summary of Chapter 4:

1. A speaker uses a changing electrical signal to make variations in air pressure.
2. All sounds are variations in air pressure that your ears feel.
3. Frequency measures how fast something occurs, and is expressed in Hertz.
4. Audio refers to the range of frequencies that can be heard by human ears.
5. Integrated Circuits are miniature circuits with many transistors, resistors, capacitors, and wires all made on a semiconductor base.
6. The ICs in Snap Circuits® are modules containing specialized integrated circuits and supporting parts that are always needed with them.

Quiz

Chapter 4 Practice Problems

1. Which of the following has the highest frequency?
   A. A stoplight repeating its green-yellow-red cycle.
   B. The minutes hand on a clock passing twelve o'clock.
   C. Your birthday.
   D. The wipers sweeping across the windshield of a car while driving in the rain.

2. The following parts can be built into an integrated circuit except:
   A. Diodes
   B. Switches
   C. Resistors
   D. Transistors

3. Which of these electrical products is least likely to have an integrated circuit in it?
   A. Lamp
   B. Garage door opener
   C. Car
   D. Radio

4. Which of the following are advantages of integrated circuits?
   A. Size
   B. Reliability
   C. Cost
   D. All of the above

Answers: 1. D, 2. B, 3. A, 4. D

SUMMARY OF COMPONENTS

Schematic Symbol	Part	Function	Qty. in SC-100R
	Wire	Connection of other components.	Various
	Battery	Produce electrical voltage using a chemical reaction.	1
	Switch	Connects or disconnects parts in a circuit.	2
	Lamp	Make light from electricity.	1
–	Printed Circuit Board	Used for mounting and connection of components.	0
–	Solder	Special metal that is melted to make solid electrical connections.	none
	Motor	Make mechanical motion from electricity.	1
–	Fuse	Used to shut off a circuit when excessive current is drawn.	0
	Resistor	Limits and controls the flow of electricity in a circuit.	1
	Photo Resistor	Light-sensitive resistor.	1
	LED	A one-way, low-current lamp.	1
	Speaker	Make sound from electricity, has low resistance.	1
	Whistle Chip	Make sound from electricity, has high resistance.	1

DEFINITION OF TERMS (also see Summary of Components pages 43–44)

Light Emitting Diode A diode made from gallium arsenide that has a turn-on energy so high that light is generated when current flows through it.

Lightning A discharge of static electricity between a cloud and the ground.

Lightning Rod A metal rod between the roof and ground, used to protect houses from lightning.

Magnetic Field The region of magnetic attraction or repulsion around a magnet or an AC current.

Magnetism A force of attraction between certain metals. Electric currents also have magnetic properties.

Milli (m) A prefix used in the metric system. It means a thousandth (0.001) of something.

Modulation Methods used for encoding signals with information.

Motor A device which converts electricity into mechanical motion.

Ohm's Law The relationship between voltage, current, and resistance.

Ohm, (Ω) The unit of measure for resistance.

Parallel Circuit When several electrical components are connected between the same points in the circuit.

Pitch The musical term for frequency.

Polarity Markings indicating which direction a device is positioned in, usually (+) and (–).

Printed Circuit Board A board used for mounting electrical components. Components are connected using metal traces "printed" on the board instead of wires.

Resistance The electrical friction between an electric current and the material it is flowing through.

Resistor Components used to control the flow of electricity in a circuit.

Schematic A drawing of an electrical circuit that uses symbols for all the components.

Semiconductor A material that has more resistance than conductors but less than insulators. It is used to construct diodes, transistors, and integrated circuits.

Series Circuit When electrical components are connected one after the other.

Short Circuit When wires from different parts of a circuit (or different circuits) connect accidentally.

Solder A tin-lead metal that becomes a liquid when heated to above 500°F. It makes a strong mounting that can withstand shocks.

Speaker A device which converts electrical energy into sound.

Static Electricity A naturally occurring build-up of electrical charge between materials, usually at high voltage.

Switch A device to connect ("closed" or "on") or disconnect ("open" or "off") wires in an electric circuit.

Transformer A device which uses coils to change the AC voltage and current (increasing one while decreasing the other).

Transistor An electronic device that uses a small amount of current to control a large amount of current.

Tungsten A highly resistive material used in light bulbs.

Voltage A measure of how strong an electric charge difference between materials is.

Volts (V) The unit of measure for voltage.

Watt (W) The unit measure for electrical power.

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