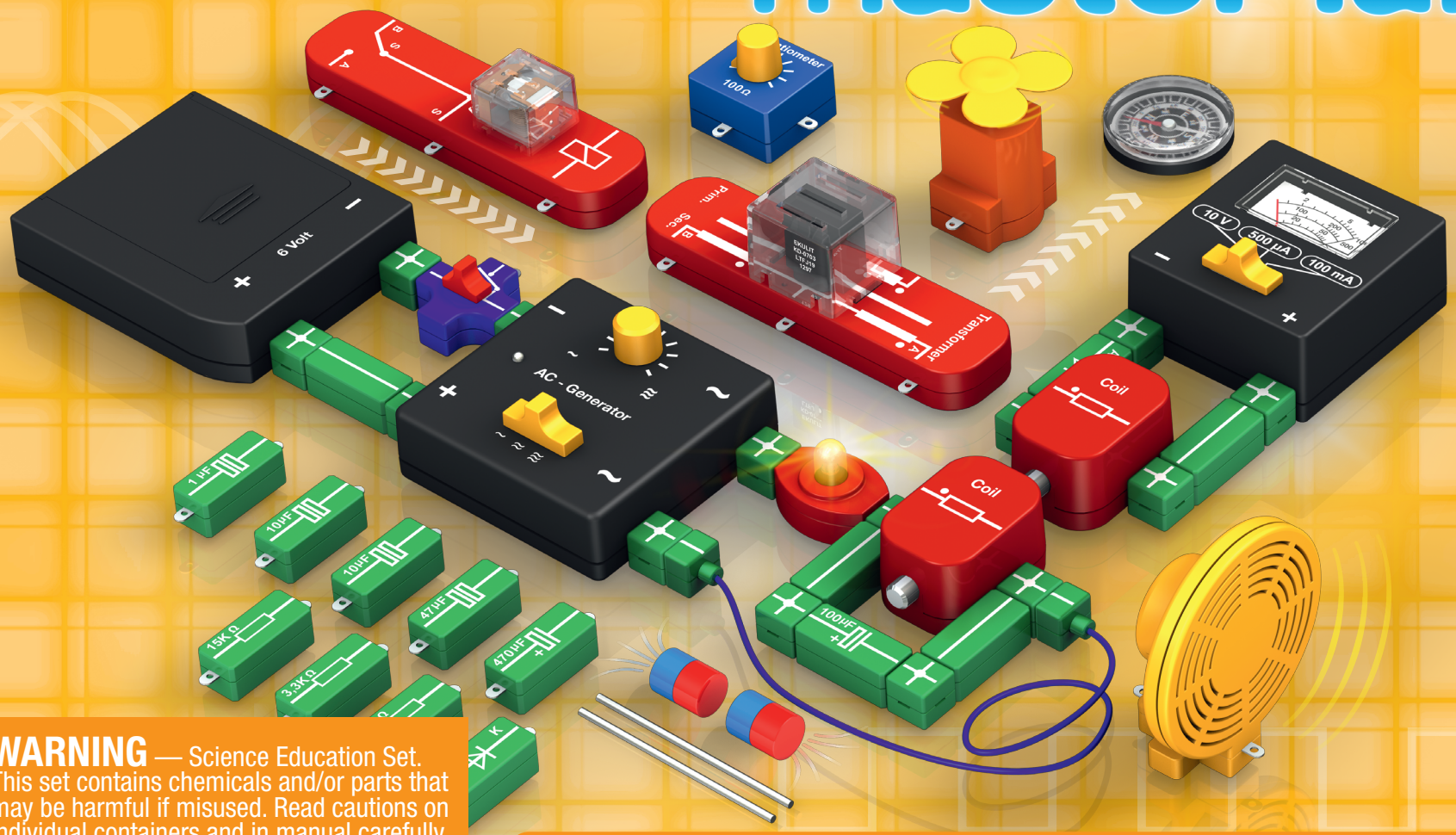
EXPERIMENT MANUAL

ELECTRICITY master lab



THAMES & KOSMOS

WARNING — Science Education Set. This set contains chemicals and/or parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.

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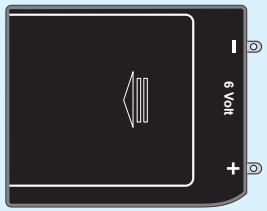
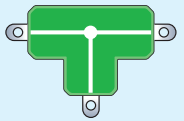
The components in your kit

This list provides brief descriptions and illustrations of all the components in this experiment kit.

You will also need:

Four AA batteries (1.5-volt, type LR6/AA), deionized or distilled water from the hardware store or supermarket, sugar, salt, cooking oil, baking soda, lemon, vinegar, citric acid, teaspoon, dishwashing liquid, glass, clean yogurt container, paper towel roll, bowl, saucer, fork, aluminum foil, tap water (warm and cold), two books, transparent tape, 30-cm ruler, metal paper clips, sheet of paper and cardboard, soft lead pencil, copper penny, zinc-coated washer (hardware store), long iron nail, and objects made of the following materials: porcelain, plastic, wood, glass, styrofoam, cork, iron, and other metals.

GOOD TO KNOW! If you are missing any parts, please contact Thames & Kosmos customer service for replacements.

Component name	Qty.	Component description	Component picture
Battery compartment Item no. 714721	1	This box supplies the current you need for all the experiments. Before starting, insert four AA batteries (1.5-volt, type LR6/AA). Then, you will be able to draw electrical current from the two terminals (+ and -). NOTE! Never connect the battery terminals directly to each other! The battery and wires could become hot and explode, and the battery will also quickly go dead.	
Selector switch Item no. 705055	2	This electrically connects two of the three contact plugs, depending on the position of the switch knob.	
Pushbutton Item no. 705054	1	This electrically connects the two terminals when you press the button.	
Connector with 4 terminals (X-shaped) Item no. 705050	25	For connecting components. The metal plugs of other components are inserted into the side slits so that they are electrically connected to each other as indicated by the white lines. In the instructions, they are called **"X-connectors."**	
Straight connector with 2 prongs (I-shaped) Item no. 705051	8	For connecting components. The two plugs are electrically connected to each other. In the instructions, they are referred to as **"I-connectors."**	
Angled connector with 2 prongs (L-shaped) Item no. 705052	4	For the electrical connection of components, but in a way that guides the current at a right angle. Looks like an "L," hence referred to as an **"L-connector"** in the instructions.	
Connector with 3 prongs (T-shaped) Item no. 705053	1	For electrical connections. The three plugs are electrically connected to each other as indicated by the white lines. In the instructions, they are referred to as **"T-connectors"** due to their shape.	

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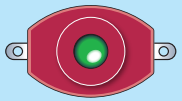
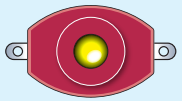
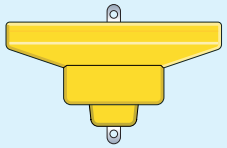
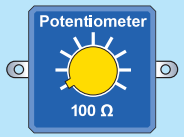
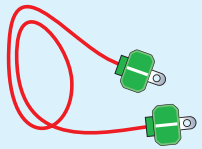
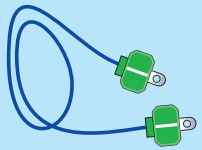
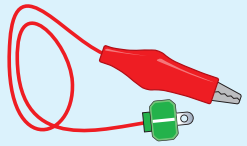
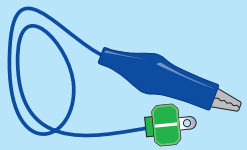
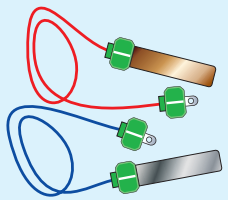
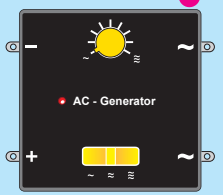
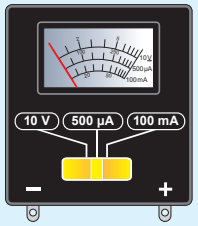
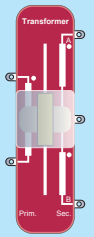
Component name	Qty.	Component description	Component picture
Red bulb (6 volts/50 mA) Item no. 714717	1	When current is flowing through it in the proper direction, this emits red light.	
Green bulb (6 volts/50 mA) Item no. 714718	1	This shines with a green light when current flows through it.	
Yellow bulb (6 volts/50 mA) Item no. 714719	1	This shines with a yellow light when current flows through it.	
Silicon diode Item no. 712926	4	An electrical valve that only allows current to flow in one direction, and blocks it in the other.	
Speaker Item no. 708805	1	This converts the alternating current oscillations into something you can hear.	
Resistor 56 ohms (56 Ω) Item no. 715367	1	Electrical resistors offer resistance to electric current — hence their name. They are used to regulate the flow of current. They come in various electrical magnitudes, indicated in “ohms” (Ω) or “kilohms” (kΩ). Resistors with larger values let less current through than ones with smaller values printed on them. CAUTION! Always use the resistor with the correct value, as specified in the assembly diagram.	
Resistor 120 ohms (120 Ω) Item no. 715368	2		
Resistor 3.3 kilohms (3.3 kΩ) Item no. 712944	1		
Resistor 15 kilohms (15 kΩ) Item no. 715369	1		

Component name	Qty.	Component description	Component picture
Potentiometer (pot) 100 kΩ Item no. 714732	1	A continuously adjustable resistor with a maximum resistance of about 100 kilohms. Informally known as a “pot.”	
Capacitor 1 microfarad (1 µF) Item no. 714740	1	Capacitors are used to store electrical charges, with current flowing when they charge or discharge. The capacitance of a capacitor is indicated in “farads.” Capacitors typically have a small capacitance indicated in “microfarads” (µF). 1 microfarad equals one millionth of a farad. With our bipolar electrolytic capacitors, unlike ordinary electrolytic capacitors like the 470-µF capacitor, you don’t have to pay attention to polarity. The 10-µF capacitor has ten times the capacitance of the 1-µF capacitor. The 47-µF capacitor accordingly has 47 times the capacitance.	
Capacitor microfarads (10 µF) Item no. 714742	2		
Capacitor 47 microfarads (47 µF) Item no. 714733	1		
Electrolytic capacitor 470 microfarads (470 µF) Item no. 712954	2	This capacitor has 470 times the electricity storage capacity of the 1-µF capacitor. Always install it as shown in the circuit diagram. WARNING! Pay attention to the proper polarity (+ and -), or the capacitor could get damaged or might even explode!	

CAUTION!
Never connect the meter directly to the battery compartment or the AC generator when it is in its current-measuring setting (100 mA or 500 µA)! The strong current would destroy its sensitive circuitry.

Component name	Qty.	Component description	Component picture
Red connecting wire with plugs Item no. 706428	1	For connecting electronic components. At the ends, there are plugs that fit into the green X-connectors. Referred to as **"red wire"** for short in this manual.	
Blue connecting wire with plugs Item no. 706429	1	For connecting electronic components. At the ends, there are plugs that fit into the green X-connectors. Referred to as **"blue wire"** for short in this manual.	
Red connecting wire with plug and alligator clip Item no. 714714	1	For making electrical connections between components without using plugs. At one end of the wire, there is a plug that fits into a green X-connector. The alligator clip at the other end "bites tight" onto another component. Referred to as **"red alligator wire"** for short in this manual.	
Blue connecting wire with plug and alligator clip Item no. 714715	1	For making electrical connections between components without using plugs. At one end of the wire, there is a plug that fits into a green X-connector. The alligator clip at the other end "bites tight" onto another component. Referred to as **"blue alligator wire"** for short in this manual.	
Electrode set Item no. 712957	1	The electrode set consists of two wires. The blue wire has a zinc plate ("zinc electrode") at one end, and the red wire has a copper plate ("copper electrode").	

Component name	Qty.	Component description	Component picture
Alternating current generator Item no. 714716	1	This instrument will use the battery current to create the alternating current required for the alternating current experiments. You can also use it to control the alternating current frequency (number of cycles per second). The alternating current generator has a range selector switch with three settings, which you can use to roughly adjust the frequency of the alternating current. All the way to the left is the lowest frequency, all the way to the right is the highest. Use the dial to adjust the frequency more precisely.	
Meter Item no. 712937 CAUTION! Be very careful with this instrument, and always be sure to follow the instructions in the manual. Otherwise it could get damaged.	1	You can use this meter to measure voltage and current strength. It has three selectable measurement settings: 10 volts (10 V) for voltage measurements, 100 milliamperes (100 mA) for current strength measurements, and 500 microamperes (500 µA) for particularly weak currents. TIP! Any meter's display has a certain amount of play. Your measurements may deviate a little from those indicated in the instruction manual.	
Transformer Item no. 714735	1	Instrument for changing alternating current voltage. It consists of three coils. One is marked "Prim." (primary coil), the others are marked "Sec." (secondary coil).	

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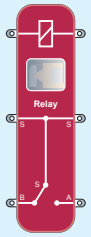
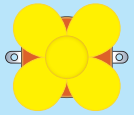
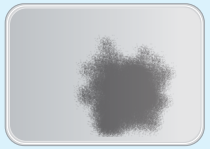
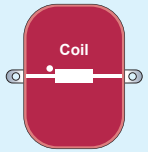
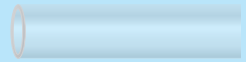
Component name	Qty.	Component description	Component picture
Relay Item no. 714729	1	An electrically activated switch.	
Electric motor Item no. 714968	1	The motor with the little propeller converts current into rotational movement.	
Neodymium magnet Item no. 714722 A particularly strong magnet without any markings on the poles.	1	WARNING! Swallowed magnets can stick together across intestines causing serious infections and death. Seek immediate medical attention if magnet(s) are swallowed or inhaled.	
Blue-red bar magnet Item no. 706423	2		
Box of iron powder Item no. 704449	1	Finely powdered iron in a sealed container. It helps to turn magnetic forces into something you can see.	
Compass Item no. 000276	1	Compass with a needle that moves easily, serving as an indicator of magnetic forces.	
Aluminum tube Item no. 714723	1	Tube made of light aluminum metal.	

Component name	Qty.	Component description	Component picture
Elastic iron strip Item no. 714724	1	A springy strip made of iron.	
Coil Item no. 714726	2	Each of these components contains several hundred coils of thin copper wire whose ends lead to contact plugs.	
Iron core for coils Item no. 714727	1	A long iron core for inserting into the center hole of a coil.	
Iron rod Item no. 714734	2	Thin rods made of iron.	
Plastic tube Item no. 714728	1	Transparent tube to keep the bar magnet from moving sideways.	
pH paper Item no. 714731	1	You can use the pH paper to determine whether a solution is acidic or basic.	
Cup Item no. 714725	1	Transparent vessel for the electrochemical experiments.	
Divider Item no. 706078	1	You can use this to separate the inserted components or connectors from each other without bending the plugs. Simply slide it between the components and push them apart.	

CHECK IT OUT

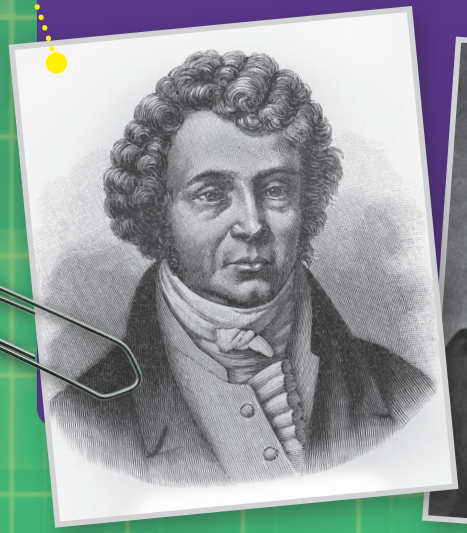
Volta and Company

The names for the most important electrical units of measurement are all based on famous scientific researchers.

The godfather of voltage was the Italian physicist Alessandro Volta (1745-1827). Among other things, he invented the electrical battery in 1801 and thus provided the first current source capable of supplying electricity for a sustained period of time.

The unit of measurement for current goes back to the French physicist André-Marie Ampère (1775-1836), who performed extensive research into electrical circuits.

The German physicist Georg Simon Ohm (1789-1854) was honored with the unit of measurement for electrical resistance — with good reason, since he was the one who discovered the relationship between voltage and current inside a circuit known as "Ohm's law."



Abbreviations at a glance

Ohm	Ω
Kilohm	kΩ
Megohm	MΩ
Ampere	A
Milliampere	mA
Microampere	µA
Farad	F
Microfarad	µF
Volt	V
Millivolt	mV

The word resistor...

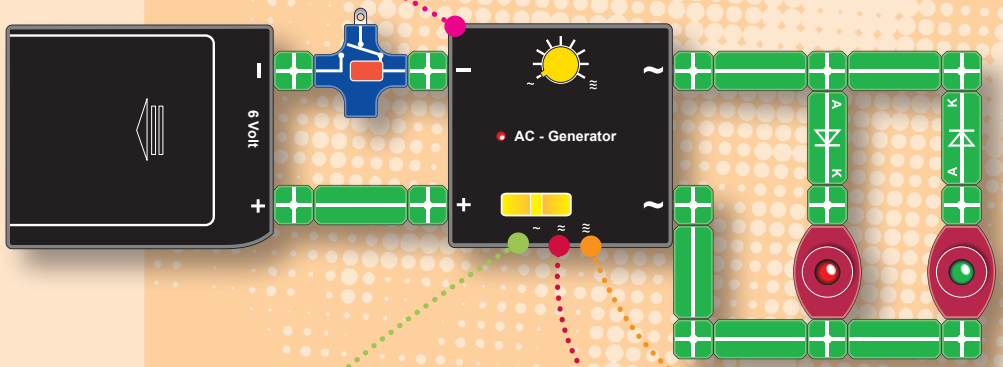
... can generally be understood to mean something that "resists" the flow of current — basically the opposite of "conductor." To an electrical engineer, it more specifically refers to a component meant to provide a certain amount of resistance within a circuit.

These kinds of resistors — usually, they look like little cylinders with two terminal wires — come in different sizes with different resistance values, or orders of magnitude of resistance. This value is printed on them in the form of a number or a color code.

EXPERIMENT 62

Automatic change of light

Changing the current's direction with the selector switches can get little bit tiresome after a while. Fortunately, your experiment kit box contains an alternating current generator to take care of it for you.



HERE'S HOW

Start by setting the AC generator's range selector switch all the way to the left at the lowest setting — the one with just a single wave.

Once you've turned on the current, you can adjust the speed of the light change by turning the dial at the top.

WHAT'S HAPPENING ?

The AC generator supplies current in a regularly alternating direction. First one diode lets it pass through, then the other. This setting of the range selector switch turns on the slowest frequency range.

If you switch to other settings, both bulbs will shine with a fairly weak light. What's happening is that they are blinking so fast that your eyes can't keep up.

TIP!

Connect the AC generator's positive and negative terminals to the battery compartment. You can then use the selector switch to turn the generator on and off. Keep this same setup for all the alternating current experiments.

The AC generator terminals marked with a "~" supply the alternating current.

HOW THE ALTERNATING CURRENT GENERATOR WORKS

The AC generator is an instrument that produces a weak voltage of about 5 volts from the battery current. You can then tap the alternating current at the two terminals marked with "~".

The alternating current's frequency (in other words, the number of alternations per second) can be set to three different levels by using the range selector switch.

The range marked with a single wave line (~) is for the slowest frequencies of about 0.3 hertz (cycles per second) to about 8 hertz. The middle range (≈) covers around 4 to 200 hertz, and the upper range (≋) supplies frequencies of 180 to around 7,000 hertz.

Within each range, you can use the dial to adjust the desired frequency. The symbols indicate the settings with the lowest and highest frequencies.

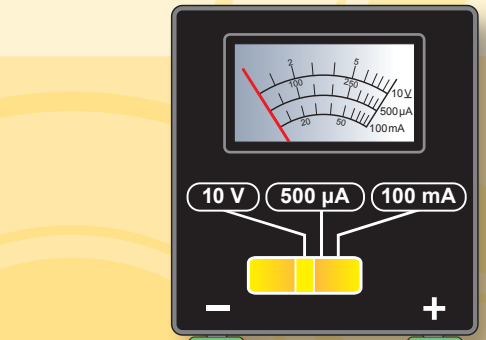
EXPERIMENT 115

Electricity from a lemon

In all your experiments so far, you got electricity from the batteries. Would you like to find out how a battery actually produces electricity?

TIP!

After the experiment, clean both electrodes with clean water and dry them carefully with a paper towel.



HERE'S HOW

Set the meter to 10 volts.

Insert the copper and zinc electrodes into the lemon a slight distance apart. Don't let them touch each other!

The needle will show a voltage of a little under 1 volt.

Switch to the 100-mA or 500-µA range. A weak current will flow here, too.

WHAT'S HAPPENING?

Over 200 years ago, the Italian researcher Luigi Galvani observed that two different metals will produce an electrical voltage if they are connected by a conductive liquid.

The physicist Alessandro Volta used this observation to construct the first electric battery. As in your experiments, it was made of copper and zinc sheets, but instead of a lemon it used a weak acid.