CURRENT, VOLTAGE, AND RESISTANCE

TOPIC:
Ohm's Law

SCIENTIST:
Georg Ohm 1787–1854

INTRODUCTION:
Georg Ohm's main scientific interest was electricity. Like that of many other scientists of his time, including Humphry Davy (1778–1829) and Michael Faraday (see 1.016), Ohm's research was made possible by the development of the voltaic pile, the first reliable source of current electricity, by Alessandro Volta (see 1.049). Ohm wanted to find out what factors affected the flow of electric current in a circuit, and he put forward a theory based on the work of French mathematician Jean Fourier (1768–1830) on heat flow. Fourier had shown that the rate of heat flow between two points was dependent on two factors: the difference in temperature between the two points and the ease with which heat was conducted by the medium that linked the two points. The greater the difference in temperature, and the greater the conductivity of the linking medium to heat, the greater the rate of heat flow. In the same way, Ohm suggested in his theory that the rate of current flow also depended on two factors: the difference in electric potential (now called "voltage") between the two points and the ease with which the wire would conduct electricity (now called "resistance"). By 1827 he was able to show that the flow of current increases as the voltage increases and the current flow decreases when the resistance increases. This relationship came to be known as Ohm's Law,* and its discovery enabled great advances to be made in the study of electricity.

*Ohm's Law states that $\frac{V}{I}$ is a constant, and that by derivation:

$$V = IR$$

where V = voltage
I = current
R = the resistance of the conductor

TIME NEEDED:
1 hour

MATERIALS:
DC power pack (producing regulated voltages between 3 and 12 volts)
2 multimeters
2 m insulated bell wire
meter ruler
Fun tak®
2 crocodile clips
wire strippers
1 m of 24 awg Nichrome wire*
graph paper
calculator

*Available from a science supply house.

Original Materials:
Ohm made his own equipment, including a galvanometer (for measuring current) and metal wire of different thicknesses. Ohm's source of electricity was a set of Leyden jars (devices invented in the eighteenth century for storing electricity) connected by brass rods.

Safety Precautions

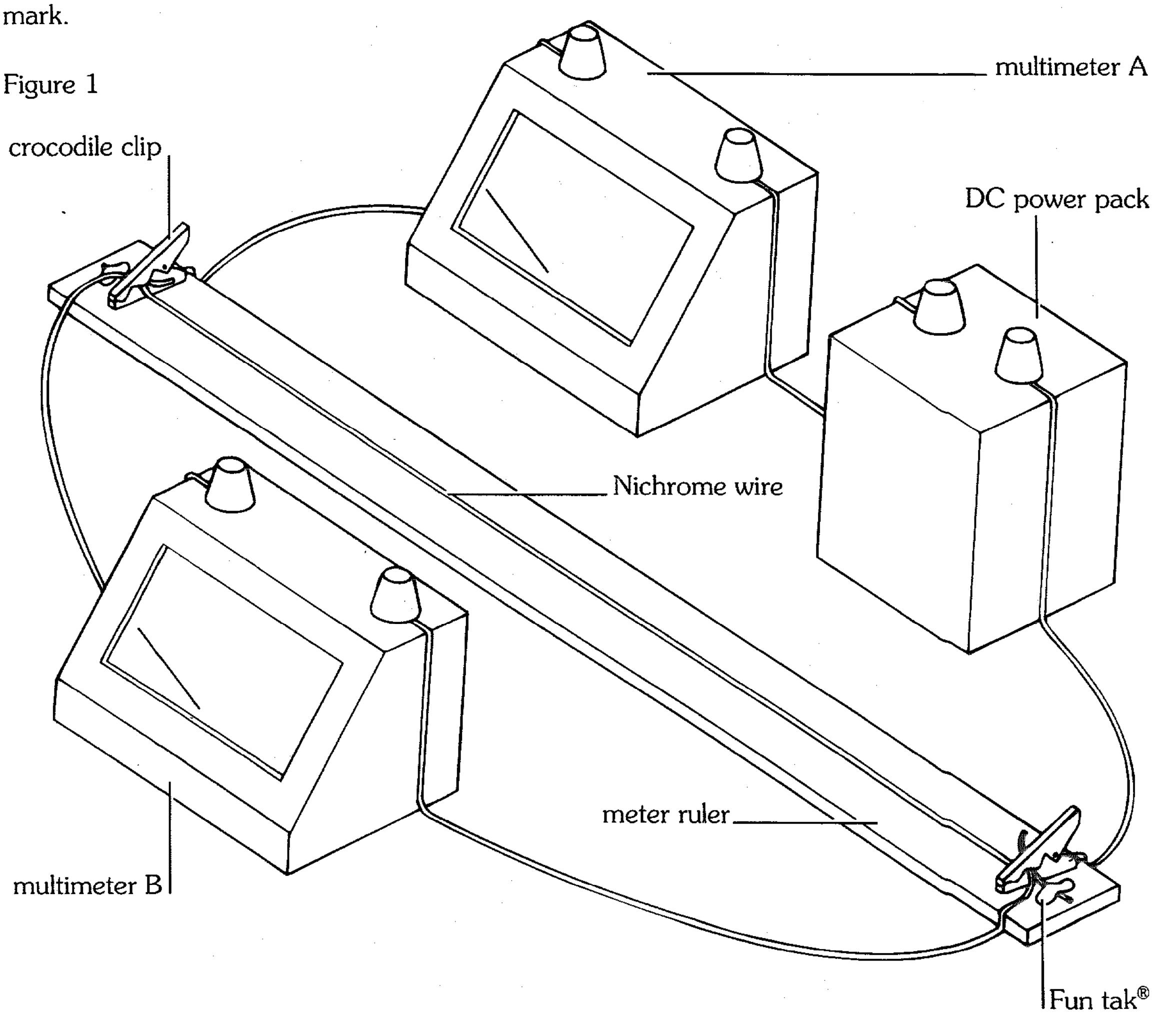
Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Electricity can cause dangerous shocks. Be careful not to expose any live wires.

PROCEDURE:

Part 1—*Measuring current flow as voltage in the circuit is increased*

1. Measure and cut five pieces of bell wire, two 25-cm long, and three 50-cm long.
2. Use the wire strippers to strip 3 cm insulation from the ends of the wires.
3. Put a small piece of Fun tak® the size of a large pea at each end of the scale (but not on the scale) of the meter ruler.
4. Stretch the Nichrome wire along the meter ruler, securing it with the two pieces of Fun tak®.
5. Look at figure 1 as a guide to positioning the wires. Take one of the shorter pieces of wire. Attach one end to multimeter A. Attach a crocodile clip to the other end of the wire and clip it around the Nichrome wire at the 0-cm mark.
6. Take one of the longer pieces of wire. Make sure the power pack is turned off. Attach one end to one of the power pack terminals. Attach a crocodile clip to the other end and clip the wire around the Nichrome wire at the 100-cm mark.
7. Take the other pieces of wire. Use the other shorter piece of wire to link the power pack to multimeter A. Attach one end of one of the longer pieces of wire to multimeter B, and open the crocodile clip at the 0-cm mark on the meter ruler so that the other end of this wire is in contact with the Nichrome wire. Take the other longer piece of wire and attach it to the other terminal of multimeter B, but clip the other end with the crocodile clip to the Nichrome wire at the 100-cm mark.

Figure 1



8. Set multimeter A to read current (probably in the 0–2A range or nearest).
9. Set multimeter B to read volts (probably in the 0–20V range or nearest).
10. Set the power pack to read 3V and switch on.
11. Record in the Data Table the values of voltage and current as displayed on the multimeters.
12. Repeat steps 10 and 11 but with the power pack now set at 4V. Then repeat in 1V steps up to 12V. Record your results in the Data Table.

Part 2—*Altering the resistance in the circuit by altering the length of the Nichrome wire*

13. Move the crocodile clip and wire that are attached to the power pack, and the end of the wire attached to multimeter B, from the 100-cm end of the meter ruler to the 80-cm mark.
14. Repeat steps 10 to 12.
15. Repeat steps 13 and 14 with the crocodile clip and wires at the 60-cm, 40-cm, and 30-cm marks.

DATA TABLE

Part 1

Voltage (volts)	Current (amps)
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Part 2

Length of wire	Voltage (volts)	Current (amps)
80 cm		
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	

Length of wire	Voltage (volts)	Current (amps)
60 cm		
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	

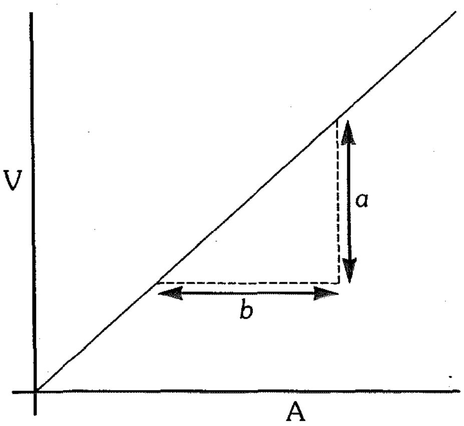
Length of wire	Voltage (volts)	Current (amps)
40 cm		
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	

Length of wire	Voltage (volts)	Current (amps)
30 cm		
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	

ANALYSIS:

1. Plot the results from part 1 on graph paper. Plot voltage on the horizontal axis and current on the vertical axis for the 100-cm length of wire.
2. Find the slope of the graph, as shown in figure 2.

Figure 2



Draw two lines from the graph as shown. Measure the distance *a* in volts and the distance *b* in amps. Divide *a* by *b* to give the slope.

3. Plot similar graphs for the results you obtained in part 2, one graph for each length of wire. Measure the slope of these graphs as described in figure 2.
4. Now, for each length of wire, plot a graph of the length of the wire along the horizontal axis against the slope of the graph for that particular length of wire along the vertical axis.

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES