THE RIGHT-HAND GRIP RULE

TOPIC:

Electromagnetism

SCIENTIST:

André-Marie Ampère 1775–1836

INTRODUCTION:

In 1820, Danish scientist Hans Oersted (see 1.037) found, by chance, that a wire carrying an electric current deflected a compass needle. He had discovered electromagnetism—the production of a magnetic field around a wire carrying an electric current. Many scientists were excited by Oersted's discovery. One of them was the French mathematician and physicist André-Marie Ampère. He worked out a rule which related the direction in which the electric current traveled along the wire to the direction in which the compass needle was deflected. Ampère's "swimmer's rule," as it was called, stated: "If an observer were to swim along the wire in the direction of the current and facing the compass needle, then the North pole of the needle would be deflected towards his/her left hand." Ampère later modified this by formulating the "right-hand grip rule." This stated that "if the wire is grasped in the right hand with the thumb pointing along the wire in the direction of the current, then the direction of the fingers, curling around the wire, will show the direction in which the compass needle will be deflected [*i.e.*, the direction of the magnetic field]." This rule anticipated Michael Faraday's (see 1.016) later theory of magnetic force which showed that the magnetic field encircles the current-carrying wire in the same way that the fingers encircle the wire in Ampère's rule.

TIME NEEDED:

1 hour

MATERIALS:

DC power pack
6 m insulated bell wire
piece of white cardboard, approximately 15 cm x 15 cm
small directional compass
iron filings (preferably in an old salt or pepper shaker)
scissors
10 paperback books (of approximately the same width)
masking tape
old newspaper
wire strippers
metric ruler

Original Materials:

Ampère would have used a more primitive battery and the wires would not have been insulated. Furthermore, he would have deduced his rule using a single wire and the compass; the coil of wire, compass, and iron filings have been used here to make the deductive process clearer.

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.

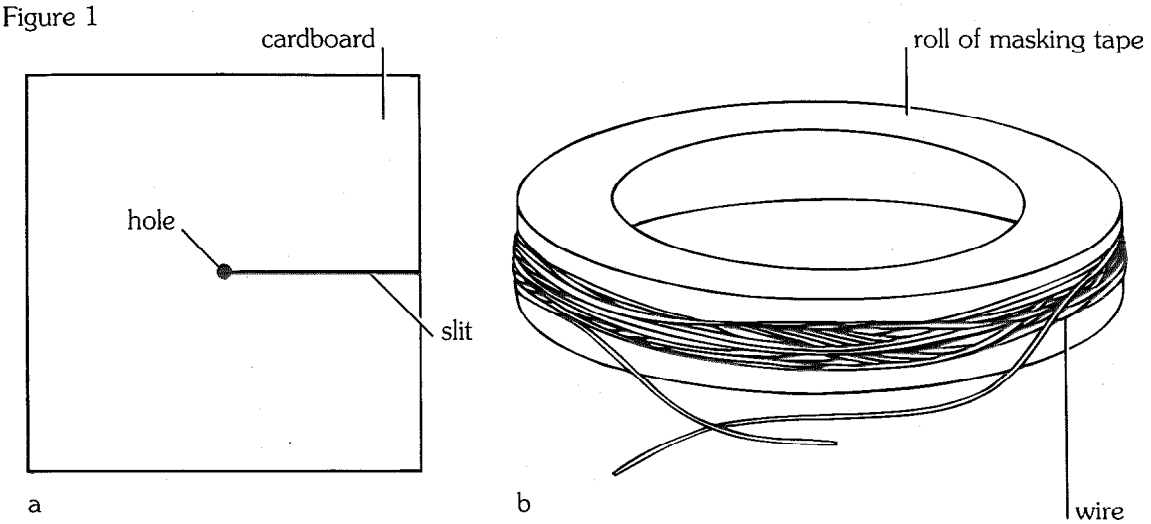
PROCEDURE:

1. Make a small hole in the center of the cardboard using the scissors. Make a slit from halfway along one edge of the cardboard to the hole in the center (see figure 1a).
2. Strip 3 cm of insulation from both ends of the wire using the wire strippers.

3. Tear off four strips of masking tape, each 10 cm long. Stick them by one end to the edge of the table, ready for use later.

4. Loop the wire repeatedly around the roll of masking tape (see figure 1b). Leave sufficient wire (20–25 cm) at both ends of the loop so that it can be linked to the terminals of the power pack.

Figure 1



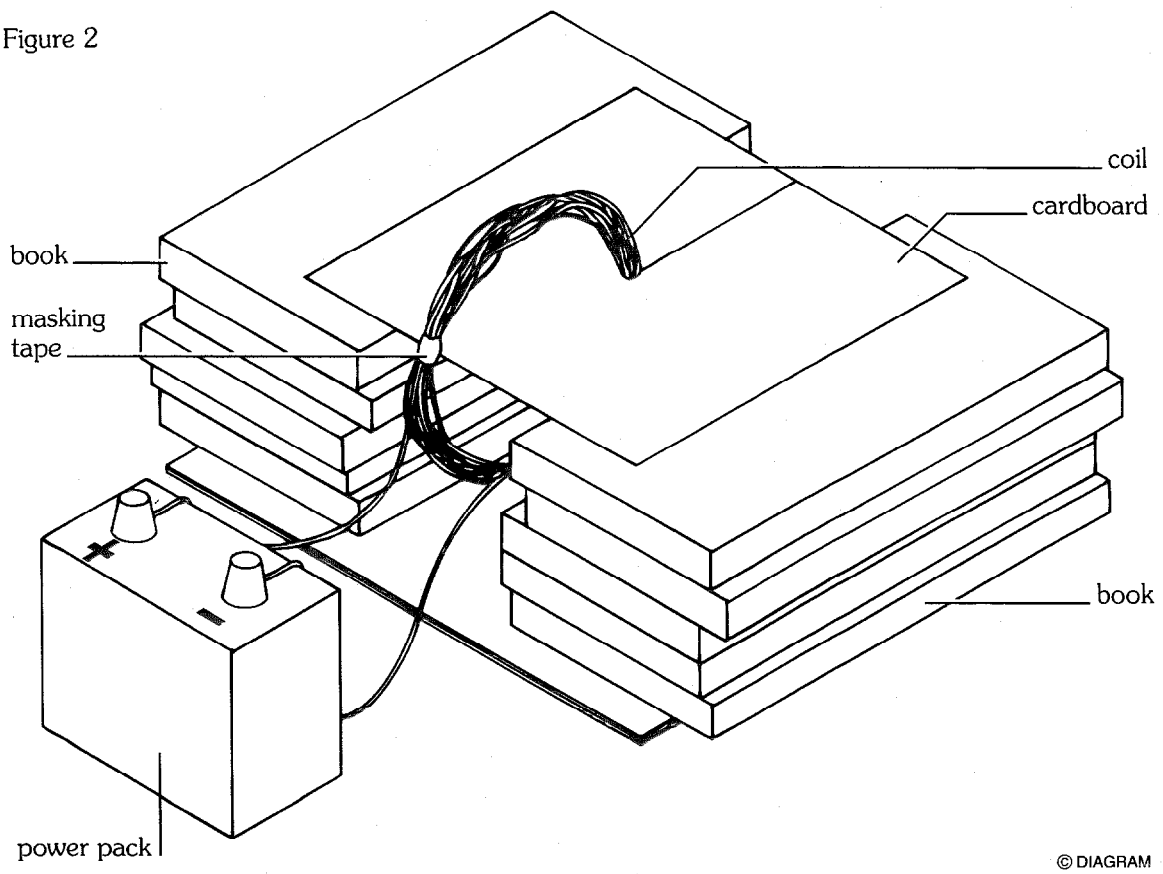
5. Carefully remove the coil of wire from the roll of masking tape. Secure the loops together at four equally spaced points along the coil using the strips of masking tape you tore off in step 3.

6. Push the coil through the slit in the cardboard so that it is running through the center (see figure 2).

7. Make two equal piles of books on the old newspaper (to prevent iron filings spilling everywhere) with a space of 9 cm between the piles. Rest the cardboard on the two piles so that the coil of wire is between them (see figure 2).

8. Sprinkle a thin covering of iron filings over the cardboard.

Figure 2



9. Connect the ends of the wire to the terminals of the power pack.
10. Look at the iron filings. Make a note of any changes that occur. If necessary, gently agitate the cardboard to jog the iron filings. Make a simple sketch of the apparatus to show which wire is attached to which terminal (either + or -).
11. Put the directional compass onto the iron filings near the center of the cardboard. Note the direction in which the needle is pointing. Move the compass from the center of the cardboard to the outside and note what happens.
12. Disconnect the circuit. Reconnect the ends of the wire to opposite terminals. Repeat steps 10 and 11.

ANALYSIS:

1. Describe what happened in step 10.
2. What happened in step 11 when you put the compass on the cardboard, and when you moved it from the center to the outside?
3. Did you notice any changes when, in step 12, you disconnected the wires and reconnected them to opposite terminals?
4. What conclusions could you draw from this experiment? (Note that electric current flows from positive [+] to negative [-]).

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