MUTUAL INDUCTION

TOPIC:

Electromagnetic Induction

SCIENTIST:

Michael Faraday 1791–1867

INTRODUCTION:

Michael Faraday's main research interest lay in the link between electricity and magnetism. In 1831 he discovered how electricity could be generated by a changing magnetic field. Faraday wrapped a length of insulated wire around one half of a soft iron ring and connected it to a galvanometer (an instrument that measures current flow). Then he wrapped a second length of insulated wire around the other half of the ring and connected it to a battery. Faraday noticed something strange. At the instant the battery was connected or disconnected, the galvanometer recorded a pulse of electricity. The rest of the time, however, the galvanometer did not respond at all. Faraday knew already that sending an electric current through one of the wire windings would turn the iron ring temporarily into a type of magnet called an electromagnet. He also knew that when the current was switched off, the iron ring would no longer be magnetic and would lose its electromagnetic field. He now realized why the galvanometer reacted the way it did. Switching the current on and off switched the electromagnetic field on and off. The sudden change in electromagnetic field induced a pulse of current in the winding connected to the galvanometer. Faraday called this induction of a current in one coil when the current is changed in another "mutual induction." He also wound the coils around a piece of lumber and obtained a similar result except that the induced current was weaker—the iron concentrated the induced magnetic field, whereas the lumber did not.

TIME NEEDED:

30 minutes

MATERIALS:

soft iron ring (*e.g.*, a machine washer available from plumbing supply stores)
or two horseshoe-shaped iron cores held together with a rubber band
DC power pack
multimeter
2 pieces of insulated bell wire, each 200 cm long
wire strippers

Original Materials:

Faraday used wire covered with silk insulation, a simple galvanometer, and an early battery to provide an electric current. He also compared the results produced with the soft iron core with those using a piece of lumber.

Safety Precautions

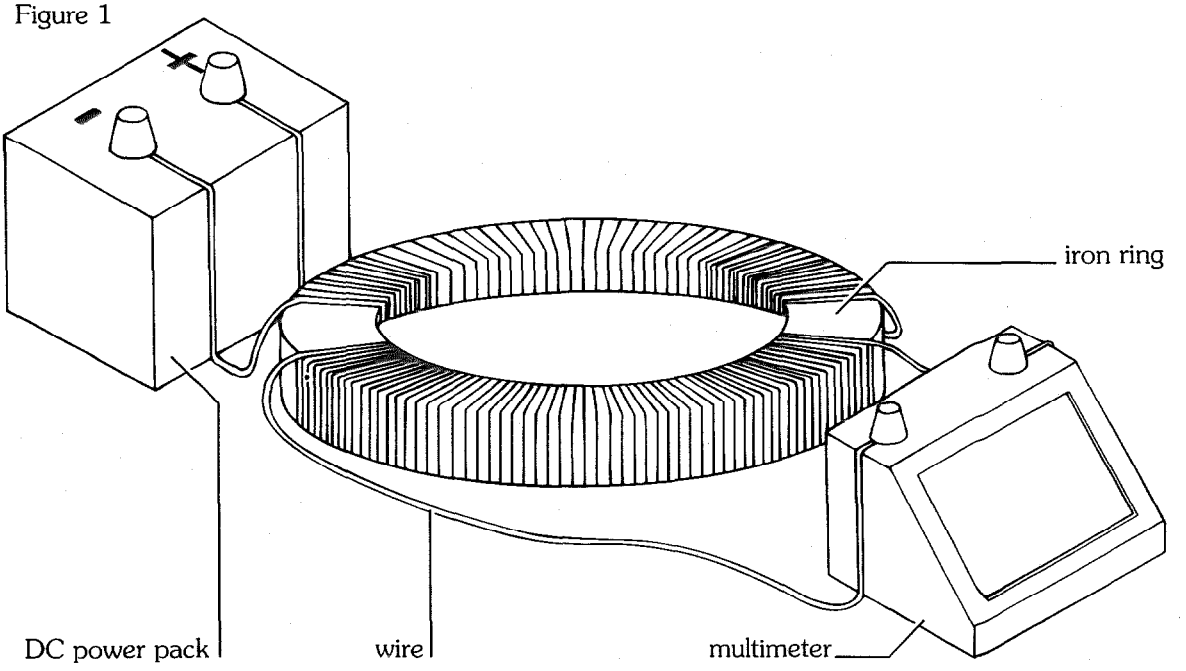
Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Electricity can cause dangerous shocks. Be careful not to expose any live wires.

PROCEDURE:

1. Wrap one of the lengths of bell wire around one half of the iron ring. After each turn, push the coils of wire close together to ensure none of the metal in that half of the ring is left exposed when you are finished. Leave 20 cm of wire unwrapped at both ends of the wire.

2. Use the wire strippers to strip 3 cm of insulation from the ends of the wire.
3. Join the free ends of the wire to the multimeter terminals (see figure 1).
4. Repeat steps 1 and 2 with the other piece of bell wire and the other half of the iron ring.
5. Connect one of the free ends of the wire to the power pack (see figure 1).
6. Take the other free end. Look at the multimeter scale. Connect the free end of the wire to the power pack. Record your observations.

Figure 1



7. Leave the wires connected for 30 seconds, then disconnect one end of the wire attached to the power pack. Record your observations when a) the circuit is left connected for 30 seconds and b) the circuit is disconnected.

ANALYSIS:

1. What happened when the circuit was connected? Explain your observations.
2. What happened when the circuit was connected and left for 30 seconds? Explain your observations.
3. What happened when the circuit was disconnected? Explain your observations.
4. Do some research. How could Faraday's discovery be used to generate electricity?

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