Make Your Own Electricity

Topic

Electromagnetic induction

Introduction

Electromagnetic induction – the creation of a difference in electric potential between the ends of a conductor moving in a magnetic field – links magnetism with electricity. If the conductor is part of a circuit, a potential difference in the conductor causes a current to flow. In this experiment, you will move a magnet within a stationary coil of wire and demonstrate some laws of induction by observing the direction and size of the current produced in the circuit connected between the ends of the coil and a current measuring device.

Time required

30 minutes

Materials

sheet of poster board ($8^1/_2 \times 11$ inches)
3 meters wire (e.g., approximately no. 20 gauge, insulated)
wire stripper
2 clip leads
digital multimeter
bar magnet (poles at ends) ($80 \times 15 \times 10$ mm)
1.5 volt D cell battery in holder
transparent tape

Safety note

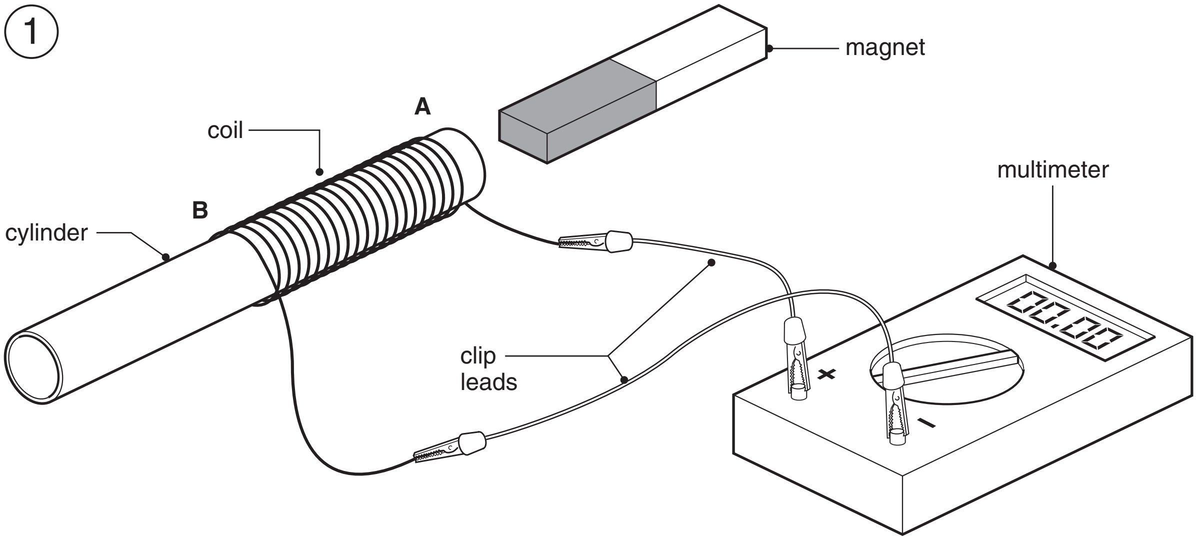
Do not use an electrical outlet.

Procedure

Part A: Making the wire coil

1. Roll the poster board to form a cylinder 20 mm in diameter. Secure with transparent tape.
2. Using the wire stripper, remove about 1 cm of insulation at each end of the wire.
3. Leaving about 20 cm of wire free, secure one end of the wire to one end of the cylinder (A in diagram 1 on the next page) using transparent tape.
4. Wrap the wire around the cylinder until you have made about 50 turns of wire. Make sure that the end leaves the coil at A in a clockwise direction when seen from the end of the coil.

5. Secure the wire to the cylinder at end B using transparent tape.



Experimental set-up

Part B: Using the wire coil

1. Attach one end of a lead to the bare wire at A on the coil and the other end to the positive terminal of the multimeter as shown in diagram 1 above.
2. Attach one end of the other lead to the bare wire at B on the coil and the other end to the negative terminal of the multimeter.
3. Switch the multimeter to read current (hundredths of an amp). Observe the meter reading while moving the North pole of the bar magnet in and out of the coil. Record the sign (positive or negative) of the meter reading when the bar moves into and out off the coil in data table A below.
4. Repeat step 3 while moving the South pole of the magnet in and out of the coil.

Data table A				
	Magnet moving			
	North pole of magnet		**South pole of magnet**	
	IN	**OUT**	**IN**	**OUT**
Sign of meter reading (+ or –)				

5. Hold the magnet in the coil (either pole in center). Record the reading on the meter in data table B on the next page.
6. Hold the magnet outside the coil (either pole towards coil) and record the reading in data table B.
7. Observe the meter reading when moving the magnet in and out of the coil quickly.
8. Observe the meter reading when moving the magnet in and out of the coil slowly.

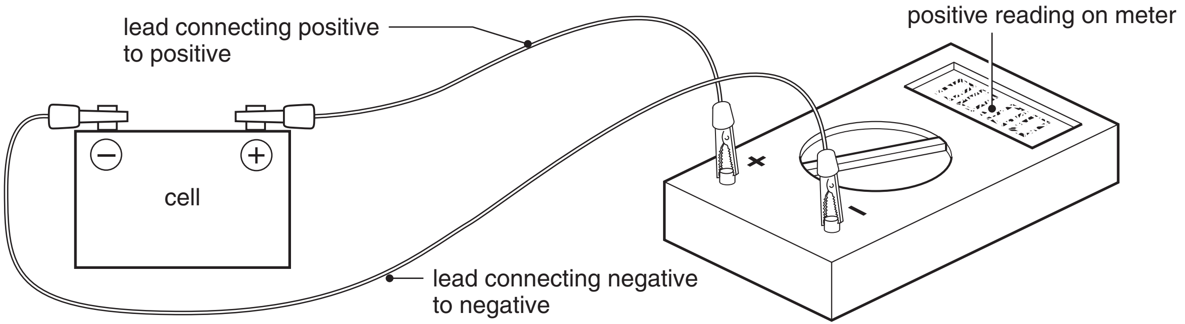
Data table B	
	Multimeter reading (amps)
Magnet stationary: within coil	
Magnet stationary: outside coil	
Magnet moved in and out of coil quickly	
Magnet moved in and out of coil slowly	

Analysis

1. What was the sign of the multimeter reading when the North pole of the magnet moved into the coil?
2. What was the sign of the multimeter reading when the North pole of the magnet moved out of the coil?
3. What was the sign of the multimeter reading when the South pole of the magnet moved into the coil?
4. What was the sign of the multimeter reading when the South pole of the magnet moved out of the coil?
5. Did the meter show a reading when the magnet was stationary?
6. Was the value of the meter reading larger when the magnet was moved quickly than when it was moved slowly?

Want to know more?

Click here to view our findings.



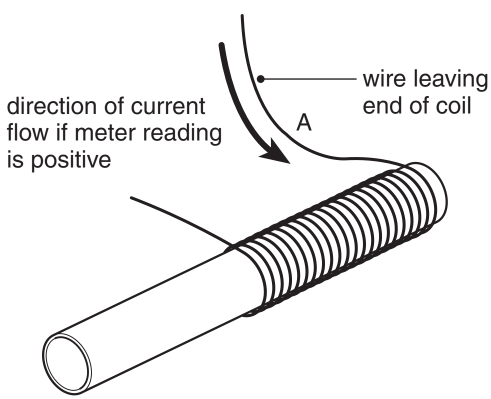
Identifying the direction of current flow

In order to understand the results of this experiment, it is necessary to identify the direction in which the current flows around the circuit when the meter reading is positive and when it is negative.

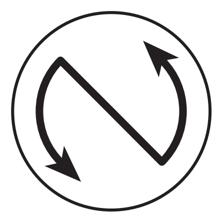
To do this, connect a cell and the multimeter as shown in the diagram on the previous page. Switch the meter on to measure current. Hold the end of the positive test lead (red) to the positive pole of the cell, and hold the end of the negative test lead (black) to the negative pole of the cell. Current flows from the positive pole of the cell to the meter and back to the negative pole of the cell; the reading on the meter is positive. Therefore, in this experiment, a positive current on the meter indicates that current is flowing from A to the meter.

1. When the North pole of the magnet moved into the coil the meter reading was negative.
2. When the North pole of the magnet moved out of the coil the meter reading was positive.
3. When the South pole of the magnet moved into the coil the meter reading was positive.
4. When the South pole of the magnet moved out of the coil the meter reading was negative.

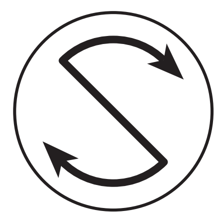
We can see from the three diagrams below that, if the current is positive, the end of the coil is acting as the South pole of a magnet and, when the current is negative, the end of the coil is acting as a north pole of a magnet.



Direction of current flow for positive meter reading



Current moves counter-clockwise around the coil



Current moves clockwise around the coil

Lenz's law states "the induced current flows in such a way as to oppose the motion or change producing it." Our results prove Lenz's law. When the North pole of the bar magnet goes into the coil, a negative current is recorded. When current flows in this direction through a coil, the end behaves like the North pole of a magnet and acts to repel the North pole of the bar magnet. Similarly, when the North pole of the magnet comes out of the coil, a positive current is recorded. When current flows in this direction through a coil, the end behaves like the South pole of a magnet (see the diagram above right) and acts to prevent the North pole of the bar magnet moving away.

5. When the magnet is stationary, no current is recorded.
6. When the magnet is moving quickly in and out of the coil, there is a larger reading on the meter than when it is moving slowly. These results follow part of Faraday's law of induction, which relates the speed with which a magnet moves relative to a conductor to the size of the induced current.