The World's Simplest Motor

P8-8300

BACKGROUND:

Use the World's Simplest Motor to study electricity and magnetism. Show energy conversions. Show how electricity creates magnetic fields and how it is used to create motion.

SCIENCE CONTENT AND STANDARDS:

Some representative national and state science content standards are given here:

Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. Magnets attract and repel each other and certain kinds of other materials. Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students understand electric motors and generators. Describe how common forms of energy can be converted, one to another.

BACKGROUND ON ELECTROMAGNETISM:

The discovery that currents produce magnetic fields was made by Hans Christian Oersted in 1820. Oersted made his discovery during a classroom demonstration on "electricity, galvanism, and magnetism." Because Oersted made his important discovery while teaching, the American Association of Physics Teachers awards a medal named after him each year to a teacher who has made a significant impact on the teaching of physics.

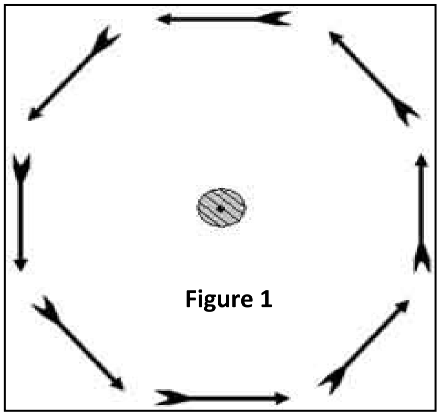
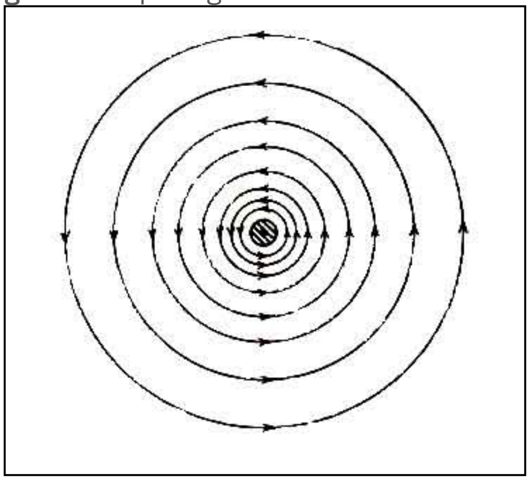


Figure 1

Fig. 1 shows a modification of Oersted's experiment. A central wire carrying a strong current is surrounded by several compass needles. The dot signifies that the current on the wire is emerging from the page. If there is no current in the wire, then the compass needles would point toward the magnetic north pole of the earth. But when a strong current is present in the wire, the compass needles align themselves with the magnetic field created by the current. Adding more compasses suggests that the magnetic field is circular and surrounds the wire, as in **Fig. 1**. This is what surprised Oersted. Not only is the field perpendicular to the current, but it is circular!

Field lines are used to represent the magnetic field in **Fig. 2**. The spacing between the lines represents the strength of the field — the denser the lines the stronger the field. Notice that the spacing of the lines increases with distance from the wire. This represents the 1/r decrease in the strength of the field — just like the decrease in the brightness of a candle.

Figure 2



Here is another representation, from a different angle, of the single wire carrying a current and the magnetic field that it creates. The Right-hand Rule can be used with a single wire to show the direction of the field lines.

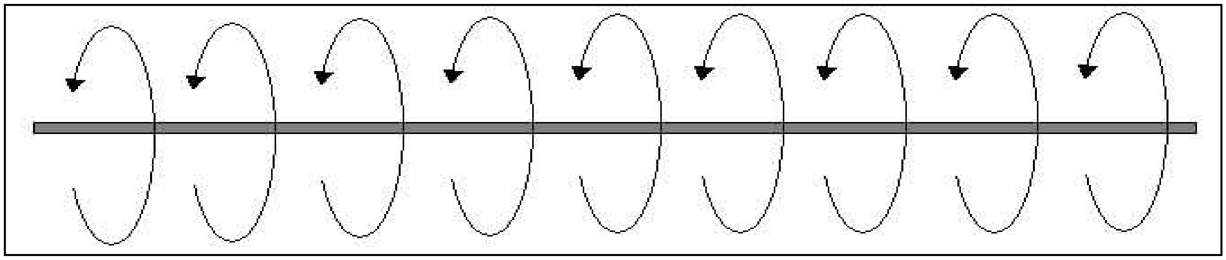


Figure 3

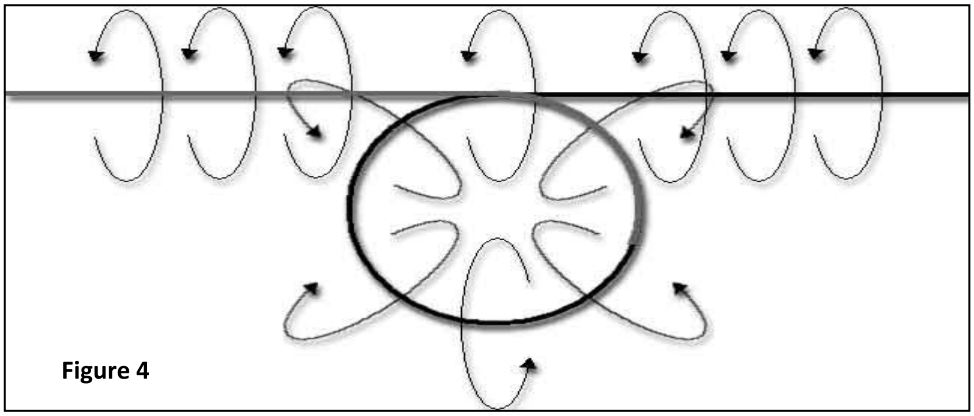


Figure 4

What happens if you put a loop in the wire, as in Fig. 4? If you follow the right-hand rule all the way around the loop, you'll see that all of the magnetic field lines inside the loop point in the same direction and field outside the loop point in the same direction. Inside the loop, however, there is a high concentration of magnetic field lines that point in the same direction. Dense field lines indicate a high magnetic field. The quantitative description of the relationship between current and the magnetic field it creates is called *Ampere's Law* and it states that the magnetic field is proportional to the current. Thus, one loop of wire, regardless of how big the wire is, will create roughly the same magnetic field as another wire, as long as the same size current runs through it. But, if there are multiple loops of wire, then *each loop creates its own field* and the magnetic field is very strong as compared to a single loop with the same size current.

In the World's Simplest Motor, the coil of wire makes a strong magnetic field when the shiny ends of the wire are down against the metal supports and a current is flowing through the wire. The coil will want to align its magnetic field with the field from the magnet. If the coil always had current flowing through it, it would tend to get stuck in one position. When properly assembled, the motor will have current for half of a turn. It will turn to try to align itself. Then the motor coasts through the other half of the turn to allow it to keep going before it is charged again. Otherwise, it would want to spin back the other way.

INSTRUCTIONS AND ACTIVITIES:

Use the Directions on the back of the package to assemble the motor. Try the experiments under the Background section above.

Also try:

- Put compasses around the magnet. Turn the magnet and see the magnetic field created. Without the magnet, place the compasses near the coil of the motor. Slowly turn the coil and show how the magnetic field is created when current is flowing through the coil. Note the direction of the magnetic field.
- Use a Magnaprobe to see the magnetic field surrounding the wire in three dimensions.
- Flip the magnet over. How does this affect the performance of the motor?

RELATED PRODUCTS:

Place small **Clear Compasses** (P8-1170) near the magnet and near the coil to see the magnetic fields.

Use Arbor Scientific's 3D compass, the **Magnaprobe** (P8-8005), with the **Magnetic Globe** (P8-1130) to demonstrate Earth's 3 dimensional magnetic field.

For more demonstrations on currents creating magnetic fields, use Arbor Scientific's **ElectroMagnet** (P8-8100).

For other activities with current and magnetic fields try Arbor Scientific's **Electric Current and Fields Kit** (P8-8008), **Electric Swing Apparatus** (P8-8009) and **Lenz's Law Apparatus** (P8-8400).

Replacement wire is also available (P8-8300-01).

BIBLIOGRAPHY:

Conceptual Physics by Paul G. Hewitt. Pearson Education, Inc.

Physics, Third Ed. Parts 1 & 2 by D. Halliday and R. Resnick. John Wiley & Sons, Inc. 1978. pp 746-762

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