615-0325 (10-148) Lenz's Law Rotary

• Experiments
• Applications
• Activities

Description: Our Lenz's Law (Rotary) Apparatus illustrates the principle of electromagnetic induction and how it relates to the Conservation of Energy.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear.

How to Teach with Energy Transfer Apparatus:
Concepts Taught: Electromagnetic Induction; Eddy Currents; Lorentz Force; Vectors; Conservation of Energy; Magnetic Flux
Curriculum Fit: Physics Sequence; Electromagnetic Induction
Grades 6-8 and up.

Theory:
What is electromagnetic induction?
What are eddy currents?
What is the Lorentz force?
What is the Conservation of Energy?
What is Lenz's Law?
What is magnetic flux?

Experiment 1: Lenz's Law – The Spinning Disk
Procedure:
1. Connect the aluminum disk with attached shaft to the plastic base.
2. Place the apparatus from step 1 on a flat surface. Make sure that the apparatus is unobstructed, so that free range of motion is allowed.
3. Using one hand, hold the base firmly, with the other spin the disk quickly using a "flick" of the wrist.
4. Bring the neodymium magnet close to the top of the disk, near the outer edge of the disk (away from the center). You should see the disk come to a stop. Refer to discussion and questions below.

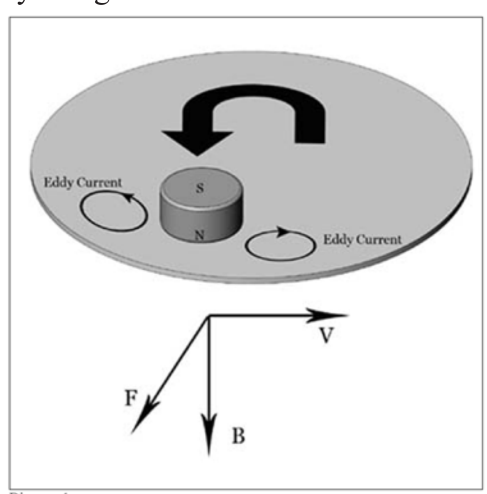

Diagram 1

Discussion and Questions:
It is well known that a magnetic field is associated with an electrical current. In experiment 1 above, free electrons in the rotating aluminum disk have a velocity, v, represented in Diagram 1 on page 3. Recall that aluminum, a metal, represents a conductor. Conductors contain movable charges of electricity or electrons. The motion of these electrons creates an electromagnetic field around the conductor.

The rotating aluminum disk represents a closed loop of moving electrons. The electrons experience a Lorentz force, which is the force exerted on a charged particle in an electromagnetic field. The electrons experience a force due to the electric field and the magnetic field. In Diagram 1, the Lorentz force, F, is radial and it points away from the center of the disk. Lorentz's Law is mathematically defined below.

$F = qvB$
q = charge of the particle (coulombs)
v = velocity of the particle (m/sec)
B = magnetic field (tesla)

The induced electric currents in the disk are referred to as eddy currents. Eddy currents occur when a moving magnetic field intersects a conductor. The current in the disk creates the electromagnet which has a magnetic field that opposes the change in the external magnetic field brought forth by bringing the neodymium magnet near the periphery of the disk. In essence, these eddy currents are used to help "brake" the disk to a stop. Thus, we have just illustrated Lenz's Law. In Lenz's Law, the induced current produced in the conductor always flows in such a direction that the magnetic field it produces opposes the change that is producing it. When the neodymium magnet moves toward the closed spinning disk, the disk sets up a magnetic field that is similar to the magnet's field (i.e., the north pole points toward the north pole of the magnet). Remember, like repels like. A greater force would need to be exerted in order to continue pushing the magnet toward the loop. This can be demonstrated by using a drill motor capable of 1,500 rpm or more. Mount the aluminum disk in the drill chuck and spin it at the highest speed. Bring the magnet close to the edge of the spinning disk. The closer the magnet gets, the harder it is repelled.

What would happen if the current was produced in the opposite direction (i.e., the south pole of the induced magnetic field is in the direction of the north pole of the magnet)?

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References:

1. Haber-Schaim, Uri, Dodge, John H., Gardner, Robert, and Shore, Edward A. PSSC Physics. Iowa: Kendall/Hunt Publishing Company, 1986. (pp. 512-527).
2. Wilson, Jerry D. Physics Laboratory Experiments. Lexington: D.C. Heath and Company, 1990. (pp. 449-451).

Related Products:

Science First® manufactures many low-cost labs that can be ordered from most science education distributors. For more information, contact us.

615-0310 Lenz's Law Demonstration – Drop the included neodymium magnet through our 2-foot copper tube. Does the magnet travel as you expect? If not, what slows it down? Includes: hollow copper tube; hollow acrylic tube - both 3/4" x 24" in size; neodymium magnet; penny for contrast; instructions.

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