EDDY CURRENTS: An Inquiry Experiment

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Many physical science/physics teachers demonstrate Eddy currents by dropping a rare-earth or cow magnet through tubes that have inside diameters slightly larger than the magnet itself. The magnet will fall freely through a 90-cm PVC tube but will fall slowly through a copper or aluminum pipe of the same length. In fact, many science supply companies offer "Eddy Current Kits" that assemble the appropriately sized pieces for an inappropriately adjusted cost. This classroom activity allows the student to explore the phenomenon in more detail to enhance her/his understanding.

Teacher Background

An eddy current is the current induced by a changing magnetic field in little swirls on a large conductor such as copper or aluminum. As the magnet falls, its field is constantly changing position. When it passes through a given portion of the metal tube, this portion of the tube experiences a changing magnetic field which induces the flow of eddy currents in the conducting material. These currents create an opposing magnetic field that exerts a braking force on the falling magnet. It falls slower! Since PVC is a non-conducting material, the magnet accelerates to Earth as expected. Eddy currents can be problematic to the engineer. They are often generated in transformers and lead to power loss. This problem is solved by constructing power transformers out of thin laminated metal strips rather than one solid piece of metal. The strips are separated by an insulating adhesive that confines the eddy currents to smaller magnitudes (and therefore smaller power losses).

Eddy currents can be put to a useful purpose. One excellent example is the magnetic damping mechanism on the beam balances in your high school science laboratory. If a large copper plate is moved through a magnetic field which intersects perpendicularly to the plate, the magnetic field will induce small circular eddy currents that will create internal magnetic fields opposing the movement. This is why a large sheet of metal rotated through a strong magnetic field exhibit a braking action. In the kit you have been given a copper disk with a hole at its center. Place a quarter-inch dowel stick through the hole as an axle. Spin the disk as fast as possible and then slide the rotating disk between the poles of a strong horseshoe magnet to observe the braking action. This simple demonstration can be related to the magnetic damping on the lab balances.

Equipment and Materials

Old hard drive (Open up the casing to reveal the freely spinning disk. You want to remove the strong magnets from the corner of the compartment. Save them for other magnet experiments!)
2 Cubic rare earth magnets (4 mm side)
Drinking straws and modeling clay
Sewing needles and thread
Large paper clips and plastic forks
Cotton string

Procedure

1. After you have demonstrated eddy currents with either the magnet falling through tubes and/or the braking action on a rotating copper disk and have discussed the principles behind the demonstration(s), place the students into experimental groups.
2. Provide each group with the prepared hard drive and the 2 magnets. You will need to caution the students on the proper handling of these powerful little magnets. Leave the other materials in a bin that they can access. You will want to have plenty of straws, forks, paper clips and needles on hand so that the students' design needs are not limited.
3. Give the students the task of using these materials to design and build an apparatus that will demonstrate eddy currents. Give them class time to brain storm ideas within their groups. Tell them that they will have to execute their plan on the following day.

Assessment

1. Prepare an assessment rubric that matches the learning level of your students.
2. If you have time, it is desirable for the groups to assess one another's work. Have each group demonstrate their finished product to their classmates. Have the audience fill in a short assessment sheet that evaluates how well the apparatus works and how well it was explained.

Extensions

1. Have students explore ways to rotate the disk at higher speeds. They could actually do a quantitative experiment to measure the relationship between the levitation height of the magnets vs. the revolutions per minute of the disk.
2. Provide students tubes or disks of differing metals such as copper, aluminum, and brass to study. Challenge them to quantitatively observe the different behaviors and relate those differences to the resistivity of the materials. (Resistivity values in microohms-centimeters for Al, Cu, and brass respectively are 3.4, 1.7, and 6.4)
3. Have students investigate the use of eddy currents in braking systems. For example, eddy currents are used to stop amusement park freefall rides such as the DropZone at the Great America Park in San Francisco.