TRANSFORMER ACCESORY KIT 2

Instruction Manual

TRANSFORMER ACCESSORY KIT 2

INTRODUCTION:

This apparatus is designed for both classroom demonstrations as well as **supervised** student use. Though the projects outlined in this kit are safe under standard operation, **dangerous voltages and currents can be created with this kit so careful supervision is required**. This kit provides means of

- Observing and understanding Lenz's law and eddy currents

CONSTRUCTION and BACKGROUND:

The kit contains 1 aluminum ring, 1 aluminum circular segment, 1 aluminum circular segment with slots, two pointed iron cones, two aluminum rods (one thick, one thin), one 90 degree brace, two bushings with lock screw. The kit is an accessory to the Demonstration Transformer Kit PH0849 which is required for operation. See the instruction manual for PH0849 for instructions and safety consideration for use of that kit.

PH0849 contains a 1200 coil solenoid. This coil is powered by a 12 VDC power supply and is used to provide the magnetic fields for this accessory. The coil should be mounted on the U-shaped iron core (U-core) for all aspects of this experiment.

If the I-shaped iron core (I-core) is mounted across the top of the U-core, the magnetization is at its strongest. By using one of the pointed iron cone and shifting the I-core slightly, we can introduce a small gap in the iron ring. Because the gap is small it has a very little effect on the magnetization of the I-core and cone. Thus, the magnetic field between the I-core and cone is very strong and can be used to explore Lenz's law and eddy currents.

Lenz's law is that a changing magnetic flux will cause an electro-motive force (EMF). If we pass a large circular ring through the gap the flux is zero before it enters the gap (no magnetic field through the ring), the flux is maximal when the ring is centered around the gap, and the flux is again zero on the far side of the gap. Since the flux is changing an EMF will be created and that EMF will cause the current to flow in the ring.

Flowing current has energy. So how did the flowing current get its energy? It came from the motion of the ring as it passed through the magnetic field. Consequently, the kinetic energy of the ring must be reduced as it passes through the magnetic field. After leaving the magnetic field the kinetic energy will remain constant.

Eddy currents are an extreme version of Lenz's law applied to a conducting sheet instead of a ring. We can think of a conducting sheet as comprised of many possible rings of different shapes and sizes. By this we means that there are lots of possible conducting loops in the conducting sheet. An infinite number, in fact. Around each conducting loop will be an EMF based on the changing magnetic flux experienced by the loop. The EMF of some loops will cancel, but many will not, especially rings larger than the I-core. Thus, large amounts of current will flow in the conducting sheet, continuously reducing the kinetic energy of the sheet. These flowing currents are called eddy currents.

This effect is demonstrated by swinging an aluminum pendulum through the gap. If set up correctly, the pendulum will immediately be brought to a halt. If we swing an aluminum pendulum which has slots cut out of it, size of the largest possible conducting loops are drastically reduced, so the pendulum won't be strongly affected by the magnetic field.

A similar test is to see what happens to a rotating aluminum disk with and without the magnetic field. Without the magnetic field, the disk will spin for a long time. With the magnetic fields, the motion of the disk is immediately stopped by the eddy currents.

Additional note to the instructor: The iron cones can be used to explore the increased magnetic field near edges and points. An explanation of this effect is not included in this guide.

WARNING!
The PH0849 kit can create unsafe voltages and should be used with extreme caution.
Consult the user manual for proper use.
WARNING!

WARNING!
The components of this kit carry the risk of electric
shock and should be used with extreme caution.
WARNING!

WARNING!
Do not try to place or remove the I-core when the primary coil is on!
WARNING!

Guide for Student use:

Eddy current braking of a pendulum

1) Mount the coil unit with 300, 600, and 1200 coils on the U-shaped iron core (U-core).

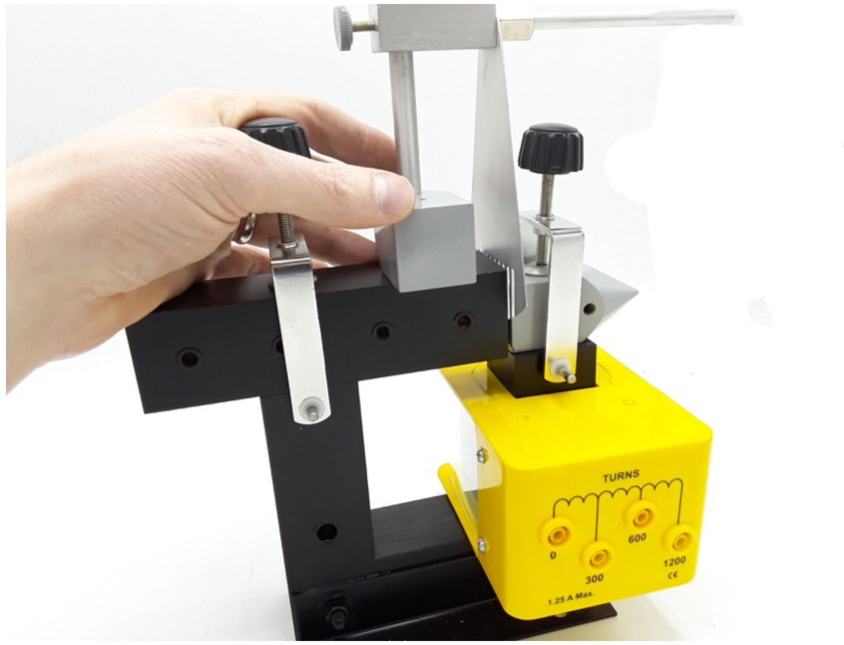
2) Secure the I-core in a ‘T’ configuration leaving a small gap (about 3 mm) between the I-core and the arm of the U-core in the transformer coil.
Place the iron cone piece on top of the coil with the point away from the I-core. Ensure that the bottom of the cone (the side away from the point) is flush with the side of the U-core.

3)
Hook up a 12 VDC variable power supply to the 300 coil connections. Adjust the voltage of the power supply so that the current is below the rated maximum. Turn off the power supply.

4) Mount the pendulum with the slots in it as shown in the picture below. The top of the slots should be just above the top of the I-core.

Use the bushing with lock screw to stabilize the pendulum so it swings smoothly when the power supply is off.

Adjust and stabilize the pendulum mount by hand.



5) Turn on the power supply an swing the slotted pendulum. Does the pendulum slow down appreciably as it passes through the gap?

6) Turn off the power supply. Replace the slotted pendulum with the pendulum without slots.

7) Swing the pendulum and then immediately turn on the power supply. What happens?

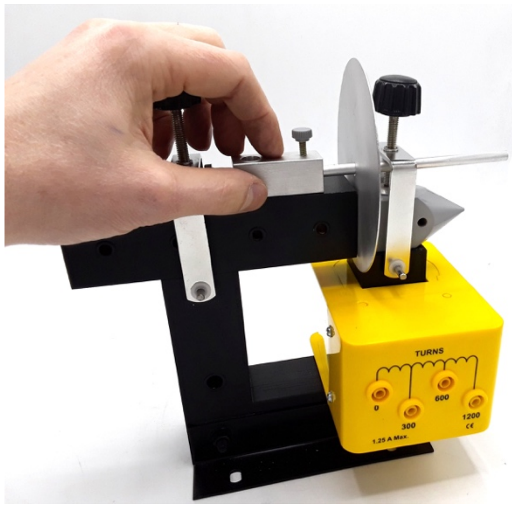
Lenz's law is that a changing magnetic flux will cause an electro-motive force (EMF). If we were to pass a large circular ring through the gap the initial flux would be zero before entering the gap (no magnetic field through the ring), maximal when the ring is centered around the gap, and again zero on the far side of the gap. Since the flux is changing an EMF is created and that EMF would cause the current to flow in the ring. The flowing current has energy which could only have come from the motion of the ring as it passed through the magnetic field. Consequently, the kinetic energy of the ring must be reduced as it passes through the magnetic field.

Eddy currents are an extreme version of Lenz's law applied to a conducting sheet instead of a ring. We can think of a conducting sheet as comprised of many possible rings of different shapes and sizes. By this we means that there are lots of possible conducting loops in the conducting sheet. An infinite number, in fact. Around each conducting loop will be an EMF based on the changing magnetic flux it experiences. The EMF of some loops will cancel, but many will not, especially rings larger than the I-core. Thus, large amounts of current will flow in the conducting sheet, continuously reducing the kinetic energy of the sheet. This is why the pendulum with no slots slows and stops when it passes through the magnetic field. The flowing currents are called eddy currents.

When we swing an aluminum pendulum which has slots cut out of it, the size of the largest possible conducting loops are drastically reduced, so the pendulum isn't strongly affected by the magnetic field.

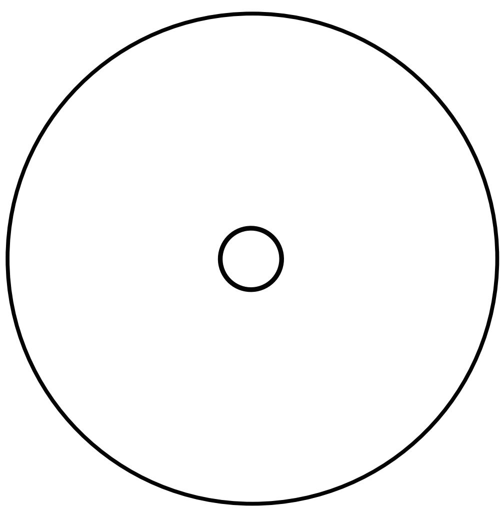
Eddy current braking of a disk

1) Turn off the power supply. Replace the pendulum setup with the disk as shown below. You'll have to carefully thread the rod through the clamp on the iron cone.



2) Spin the disk and immediately turn on the power supply. What happens?

3) Draw a possible configurations of slots which would eliminate the eddy current braking effect.



4) Can you think of any settings where this approach to braking would be useful?

5) Can you think of any drawbacks to this braking approach?