PHYS 1402
General Physics II

EXPERIMENT 6
ELECTROMAGNETIC INDUCTION

I. OBJECTIVE

The objective of this experiment is to qualitatively study Faraday's law of electromagnetic induction and Lenz's law. The student will determine the direction of the current induced in a coil as a result of a change in the magnetic flux inside the coil. This change in the magnetic flux will be produced by inserting and removing either a bar magnet or an electromagnet in the coil.

II. THEORY

According to Faraday's Law of induction, if a permanent magnet, B_{original}, is inserted into (or pulled out of) a coil, a current is induced in the windings of this coil, I_{ind}. This current is maintained only when the magnet is being inserted into or pulled out of the coil. The presence of the induced current will make the coil an electromagnet, B_{ind}. It has a N and S poles and like any other magnet, it will exert forces on other magnets and magnetic materials. According to Lenz's law, the direction of the induced current is such that it's magnetic field, B_{ind} will oppose the change in B_{original}. According to the **right hand rule** , if you grasp the coil in your right hand such that your fingers point in the direction of the induced current in the windings, the thumb will point towards the N pole of the electromagnet. The other end is the S pole.

III. APPARATUS

Galvanometer, primary and secondary coils, 1.5 V battery, bar magnet, aluminum rod, iron rod, and connecting wires.

IV. EXPERIMENTAL PROCEDURE

1. **Convention:** When the electric current enters the galvanometer (or the ammeter) through the positive (red) terminal, the needle deflects to the right. This convention will help us determine the direction of the current induced in the solenoid.

2. Examine the large solenoid (called the secondary) and note the two small holes at the bottom with wire coming out of them. These will help you determine the direction of the induced current in the solenoid. This determination is very important in this experiment since it allows you to determine whether your observations are consistent with Lenz's law.

3. Connect the galvanometer to the large solenoid as shown in Figure (1).

4. Insert the north pole of the magnet into the solenoid and observe the deflection of the galvanometer. From this observation, try to figure out the direction of the induced current in the windings of the solenoid. Use the right

hand rule to figure out which end of the coil is the north pole and which end is the south pole. Draw a diagram (similar to Figure (1)) and on it show the motion of the magnet, the direction of induced current flow in the solenoid and the N and S poles of the solenoid.

5. Observe the effect of the speed of the bar magnet on the magnitude of the induced current.
6. Move the magnet away from the coil and record observations similar to those in steps (4) and (5).
7. Hold the magent with the S pole closest to the solenoid and repeat steps (4), (5) and (6).
8. Determine whether the induced field of the solenoid attracts or repels the permanent magnet in each case. Is this opposing the motion of the magnet or helping it in each case?

Figure (1)

9. Now the permanent magnet will be replaced with an electromagnet (solenoid connected to a battery) and the four cases will be repeated. Connect the primary coil to the 1.5 V battery as shown in Figure (2). Repeat steps (4), (5), (6) and (7) using the primary solenoid as the "magnet".
10. With the primary connected to the 1.5 V battery, insert it into the secondary. Now disconnect it from the battery and observe the deflection. Reconnect it to the battery and observe the deflection. Draw two diagrams similar to the ones above.
11. Insert an iron rod into the primary and record its effect on the magnitude of the induced current as you disconnect and reconnect to the battery.

V. ANALYSIS

1. Draw diagrams like Figure (1) showing the direction of the induced current in the solenoid. Indicate which end of the solenoid is N and which end is S. Next to the diagram, indicate whether the force between the bar magnet and the elctromagnet is attraction or repulsion. Is this force consistent with Lenz's Law? You should have 10 such diagrams: four using the permanent magnet, four using the primary coil as the magnet and two more disconnecting and reconneting the primary while it is inside the secondary.