Exercise 6: Lenz's law of electromagnetic induction

Purpose: to determine the direction of the induced emf and current in a closed circuit loop from a time changing magnetic flux.

Introduction

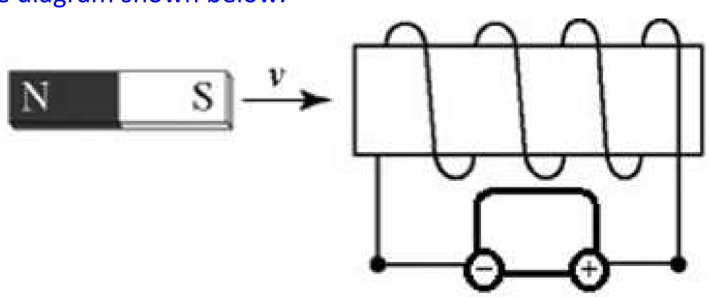
Magnetic flux is the amount of magnetic field vector passing through a given area. Faraday's Law states that a time changing magnetic flux through an area bounded by a closed circuit induces an emf that drives the flow of current around the circuit. Lenz's Law gives a quick reference to the direction of the emf in a circuit loop as explained more completely explained by Faraday's law. Lenz's law states that the polarity of the induced emf produces a current that creates a magnetic flux which opposes the external change in magnetic flux.

We can see the direction of the current induced in a solenoid from a time changing magnetic field by observing the needle of a galvanometer. A galvanometer reads a positive current when the current enters the positive (+) input terminal and leaves through the negative (–) terminal. It reads a negative current when the current enters the negative (-) terminal and leaves the positive (+) terminal.

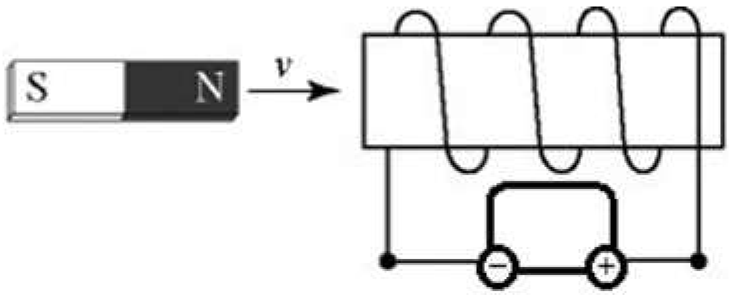
The magnetic field lines external to a bar magnet go from the N pole to the S pole. Since magnetic field lines are continuous, that is, they do not start or end anywhere, the field lines inside the bar magnet must necessarily go from the S pole to the N pole. This situation is in contrast to electric field lines, which do begin and end at electric poles (at positive and negative charges). All the magnetic field lines outside the magnet must be squeezed together as they pass through inside, going the opposite direction. If this is confusing, draw a simple diagram of a bar magnet, and add field lines to your drawing both inside and outside the magnet, indicating the directions of the fields with arrows.

Laboratory assignment

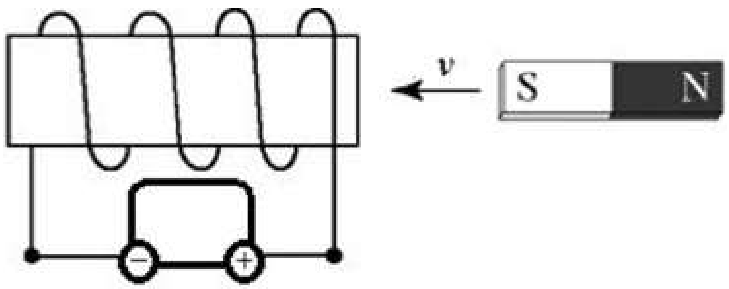
1. Connect the galvanometer to the solenoid. Note how the coil wraps and how the wires are connected to the galvanometer in the diagram below step 4. All of the diagrams are for counter-clockwise winding towards the observer when looking down either end of the solenoid. If your solenoid has the opposite winding, then you will need to hook up the galvanometer differently than shown below. As shown, left wire in (-) and right wire in (+). If you have opposite wiring then left wire in (+) and right wire in (-).
2. First, move the bar magnet in and out one end of the solenoid to see if the meter responds. If the galvanometer does not respond, then ask your instructor for help.
3. Starting with the magnet far from the galvanometer, push the bar magnet, leading with the south pole, from the left and toward the solenoid until it is partial inside. Perform this task with a fair amount of speed to observe a large signal.
4. Draw i) the direction of current in wire [use the right hand rule] and ii) the galvanometer needle direction in the diagram shown below.



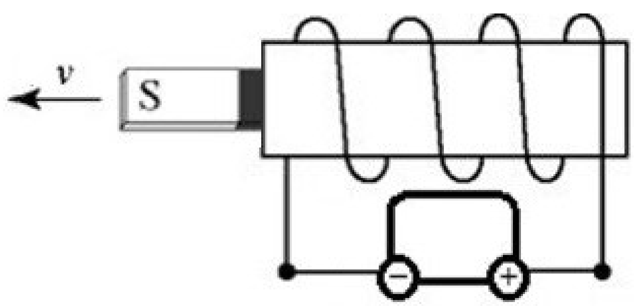
5. Starting with the magnet far from the galvanometer, push the bar magnet, leading with the north pole, from the left and toward the solenoid until it is partial inside.
6. Draw i) the direction of current in wire and ii) the galvanometer needle direction in the diagram shown below.



7. Starting with the magnet far from the galvanometer, push the bar magnet, leading with the south pole, from the right and toward the solenoid until it is partial inside.
8. Draw i) the direction of current in wire and ii) the galvanometer needle direction in the diagram shown below.

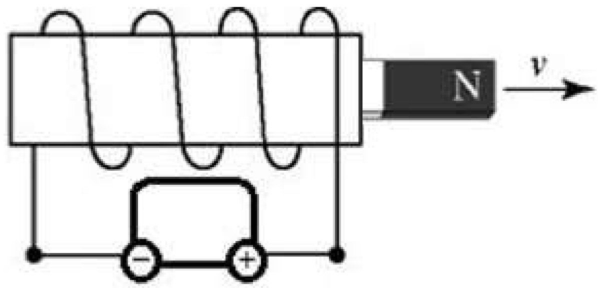


9. Starting with the magnet partially inside the left side of the solenoid with the north pole being inside the solenoid and south pole being outside the solenoid, pull the bar magnet to the left until it is away from the solenoid.
10. Draw i) the direction of current in wire and ii) the galvanometer needle direction in the diagram shown below.



11. Starting with the magnet partially inside the right side of the solenoid with the south pole being inside the solenoid and north pole being outside the solenoid, pull the bar magnet to the right until it is away from the solenoid.

12. Draw i) the direction of current in wire and ii) the galvanometer needle direction in the diagram shown below.



13. Perform any one of the experiments above and vary the speed of the magnet. What effect does varying the speed with which you insert or remove the magnet from the solenoid have on the induced emf in the solenoid? Explain your observations using Faraday's Law.

____

____

____.

14. Under what conditions does a current flow in response to a magnetic field? For instance, how about when the magnet is at rest in the solenoid? Explain in detail.

____

____

____.

15. Perform another set of experiments to answer the following questions. Can you cause a current to flow in the solenoid by moving the bar magnet along the outside of the solenoid rather than inside the solenoid? If so, are certain orientations of the magnet more effective than others for inducing this current? Observe and explain.

____

____

____

____.

16. Write a conclusion to this laboratory.

____

____

____

____

____

____

____

____

____

____

____

____.

Equipment list: bar magnet, solenoid, banana cords, galvanometer.