

# LABORATORY VI

## ELECTRICITY FROM MAGNETISM

In the previous problems you explored the magnetic field and its effect on moving charges. You also saw how magnetic fields could be created by electric currents. This lab will carry that investigation one step further, determining how changing magnetic fields can give rise to electric currents. This is the effect that allows the generation of electricity, which powers the world's technology.

The problems in this laboratory will explore different aspects of changing the magnetic flux through a coil of wire to produce an electric current. You will investigate the current produced in a coil of wire by moving the coil, moving the magnet causing the magnetic field, changing the area of the coil perpendicular to the magnetic field, and changing the magnetic field.

### OBJECTIVES:

After successfully completing this laboratory, you should be able to:

- Explain what conditions are necessary for a magnetic field to produce an electric current.
- Determine the direction of a current induced by a magnetic field.
- Use the concept of magnetic flux to determine the electric effects of a changing magnetic field.
- Use Faraday's law to determine the magnitude of a potential difference across a wire produced by a change of magnetic flux.

### PREPARATION:

Read Serway & Jewett: Chapter 23, sections 1-4.

Before coming to lab you should be able to:

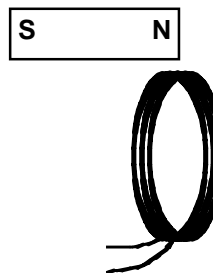
- Use a DMM to measure current, potential difference, and resistance.
- Sketch the magnetic fields from permanent magnets and current carrying coils of wire.
- Use vector addition to combine magnetic fields from several sources.
- Use the right-hand rule to determine the direction of the magnetic fields from circuit loops and wires.
- Use a Hall probe to determine the strength of a magnetic field.
- Use the definition of magnetic flux.

# PROBLEM #1: MAGNETIC INDUCTION

One of the great technical problems in modern society is how to generate enough electricity for our growing demand. You have been assigned to a team that is investigating efficiency improvements for electric generators. Before becoming involved with a lot of math and computer simulations, you decide to get a feel for the problem by seeing how many different ways you can generate a potential difference using a bar magnet and a coil of wire, and how you can influence the size of that potential difference.

## EQUIPMENT

You will have a small coil of wire and a bar magnet. You will use the LabPro interface and the Faraday Probe (*Appendix D*) to convert the potential difference into a digital signal suitable for your computer data acquisition program (see *Appendix E*) which records time varying potential differences.



## PREDICTION

Read Serway & Jewett: sections 23.1, 23.2, 23.3.

How can you use the magnetic field of the bar magnet to induce a potential difference across the ends of a coil of wire? How many different ways can you think of? What influences the size of the potential difference? For each method, draw a picture of your procedure(s) to induce the current in the coils.

## EXPLORATION

If necessary, disconnect the magnetic field probe from the LabPro interface. Plug the Faraday Probe into the LabPro interface (*Appendix D*). Attach the clips to the two ends of the coil and start the FaradayPROBE program (*Appendix E*).

Use the magnet and the coil to make sure that the apparatus is working properly and that you are getting appropriate potential difference graphs on the screen.

From your predictions, how many different motions did members of your group think of to induce a potential difference across the ends of the coil? List them in your journal. Test each method and record the results. Did any method not produce a potential difference? For each method, what factors affect the magnitude and sign of the induced potential difference? *Make sure everyone gets a chance to manipulate the magnet and coil and control the computer.*

Can you discover any methods you didn't think of earlier? What is the largest potential difference you can generate?

<b>CONCLUSION</b>
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How do your results compare with your predictions? Explain any differences.

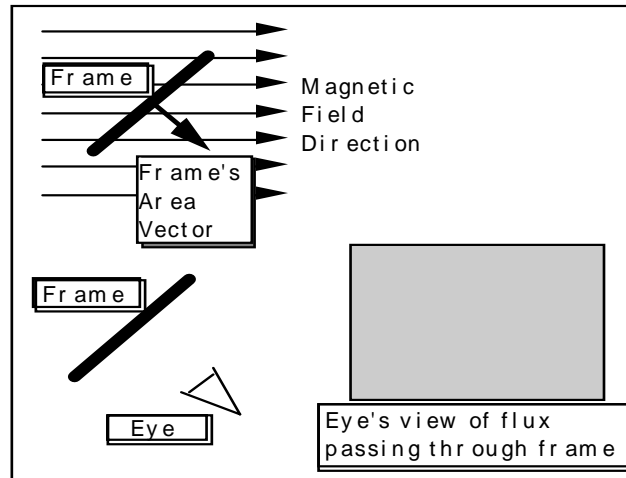
List the important characteristics for inducing a potential difference in the coil of wire. Explain how they are related to the magnitude and sign of the induced potential difference (the sign of your measured induced potential difference will depend on how your Faraday Probe is hooked up to the coil). How do you get the largest potential difference?

## PROBLEM #2: MAGNETIC FLUX

You have produced a potential difference in a coil of wire by changing the amount of magnetic field passing through it. However, a literature search on the web shows that most existing generators use mechanical means such as steam, water, or airflow to rotate coils of wire in a constant magnetic field. To continue your design of a generator, you need to calculate how the potential difference depends on the change of orientation of the coil with respect to the magnetic field. A colleague suggests you use the concept of magnetic flux that combines both the magnetic field strength and the orientation of the coil with respect to the magnetic field direction. You decide that you need to calculate the magnetic flux through the coil as a function of the angle between the coil and the magnetic field. To help you qualitatively check your calculation, you use a computer simulation program. You then quantitatively test your calculation by modeling the situation in the laboratory.

### EQUIPMENT

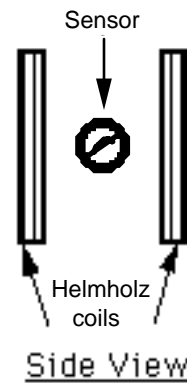
See [Flux Simulator](#) in *Appendix E*.



Picture of [Flux Simulation](#) Screen

To make the measurement, a magnetic field sensor (Hall probe) is placed midway between two Helmholtz coils as shown to the right. The sensor can be rotated about a vertical axis and the angle of rotation measured. The sensor measures the amount of magnetic field perpendicular to the area of the Hall effect chip (white dot).

The magnetic field application written in LabVIEW™ will be used to analyze the measurements obtained with the magnetic field sensor (HallPROBE).





**WARNING:** You will be working with equipment that generates large electric currents. Improper use can cause painful burns. **To avoid danger, the power should be turned OFF and you should WAIT at least one minute before any wires are disconnected from or connected to the power supply.**

**PREDICTION**

Calculate the magnetic flux through an area (the frame of the simulation or the Hall effect transducer chip for the measurement) as a function of the angle that the area makes with the direction of the magnetic field. Use this expression to graph the magnetic flux versus angle.

In the simulation program, under what conditions will the “eye see” the most intense blue color? The most intense red color? Will there ever be no color, or white? As the Frame is slowly rotated, will the transitions in intensity be sudden, or gradual? Is the change in intensity linear or something else?

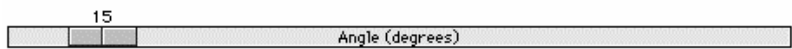
**WARM-UP**

Read Serway & Jewett: sections 23.1, 23.2, 23.3.

1. Draw the coil of wire at an angle to a magnetic field.
2. Draw and label a vector that you can use to keep track of the direction of the coil. The most convenient vector is one perpendicular to the plane of the coil, the area vector. Label the angle between the area vector and the magnetic field.
3. The magnetic flux for a constant magnetic field is the component of the magnetic field perpendicular to the plane of the coil times the area of the coil. Write an equation for the magnetic flux through the coil as a function of the strength of the magnetic field and the angle between the area vector and the magnetic field direction. For what angle is this expression a maximum? Minimum?

**EXPLORATION**

Open the Flux Simulator movie. Use the control bar with slider, which advances through the movie, to control the rotation of the frame. Try it.



Slider

As you rotate the frame, observe both the angle that the frame's area vector makes with the magnetic field and the color seen by the eye. Is this what you expected the eye to see? Why or why not?

Now examine the apparatus with which you will make your measurement. Don't forget to calibrate the Hall probe before you turn on the coils. Decide whether you should set the amplifier to high or low sensitivity. You will want as large a magnetic field as you can produce safely with the equipment available.

Check to see if the magnetic field varies in time. Move the sensor slightly without changing its orientation to see if the magnetic field changes with position in the region of the sensor. If it does, this will add to the uncertainty of your measurement.

Slowly rotate the Hall Probe sensor through a complete circle noting the size of the readings. What is the best way to read the angle? When you return to the same angle, do you get the same reading? For what orientation is the magnetic flux largest? Smallest? Is that as you expected?

Make sure you understand the correspondence between the simulation program, the measurement apparatus, and the objects in the problem statement.

**MEASUREMENT**

Use the Hall probe to measure, for a particular angle, the magnitude of the magnetic field between the Helmholtz coils. Rotate the probe through 360 degrees, making measurements at whatever angle intervals you think are appropriate. Include uncertainties with your data.

**ANALYSIS**

Describe the color and intensity change seen by the eye as the frame rotates. What does this represent?

After the Hall probe measurement, choose an equation, based upon your prediction, that best represents your data points and adjust the coefficients to get the best correspondence with the data.

**CONCLUSION**

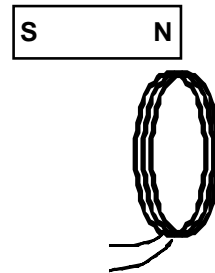
How is the magnetic flux through the coil dependent on the angle it makes with the magnetic field? Is the flux ever zero? When is the flux a maximum? How did the results compare to your prediction?

### PROBLEM #3: THE SIGN OF THE INDUCED POTENTIAL DIFFERENCE

To continue your investigation of how to improve the efficiency of electric generators, you decide to determine how the sign of the induced potential difference across the ends of a coil of wire depends on the physical arrangement and relative motions of your materials. You decide to start your investigation with the simplest situation possible – a coil of wire and a bar magnet.

#### EQUIPMENT

You will have a small coil of wire and a bar magnet. You will also have a computer data acquisition system with an application written in LabVIEW™ to display potential difference as a function of time (see Appendix E).



#### PREDICTION

Draw a coil of wire wrapped either clockwise or counterclockwise with the two ends of the wire protruding as shown in the above diagram. Add a bar magnet being pushed through the center of the coil in one direction.

Given the orientation of coil and magnet you have chosen, which of the protruding wires would you expect to be at a higher potential when :

- i) The north pole of a bar magnet is pushed through the coil in the direction you've chosen.
- ii) The south pole of a bar magnet is pushed through the coil in the direction you've chosen.

#### WARM-UP

Read Serway & Jewett: sections 23.1, 23.2, 23.3.

1. Draw a picture of each situation. Draw and label the velocity vector of the magnet relative to the coil. Also draw the direction of the magnetic field vectors in the coil.
2. Use Lenz's Law to relate the changing flux through the coil to the sign of the potential difference induced across the ends of the coil? How does the induced potential difference across the ends of the coil relate to the induced current in the coil?

#### EXPLORATION

If necessary, disconnect the magnetic field probe from the LabPro interface. Plug the Faraday Probe into the LabPro interface. Attach the clips to the two ends of the coil and start the FaradayPROBE program.

Use the magnet and the coil to make sure that the apparatus is working properly and that you are getting appropriate graphs of potential difference as a function of time on the screen.

Push one end of the magnet into the coil and note the sign of the induced potential difference. Is the sign of the induced potential difference the same if you hold the magnet steady and instead move the coil? How does changing the velocity of the moving magnet (or the moving coil) change the magnitude and sign of the induced potential difference?

How does the sign of the induced potential difference change when you (i) push the magnet into the coil; (ii) leave it in the coil without moving, and (iii) pull it out of the coil?

What happens if you move the magnet next to the coil? Try it.

<b>MEASUREMENT</b>
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Determine the sign of induced potential difference across the ends of the coil when you push the north pole of the magnet through the coil and when you push the south pole of the magnet through the coil.

Repeat the measurements, but this time keep the magnet still and move the coil.

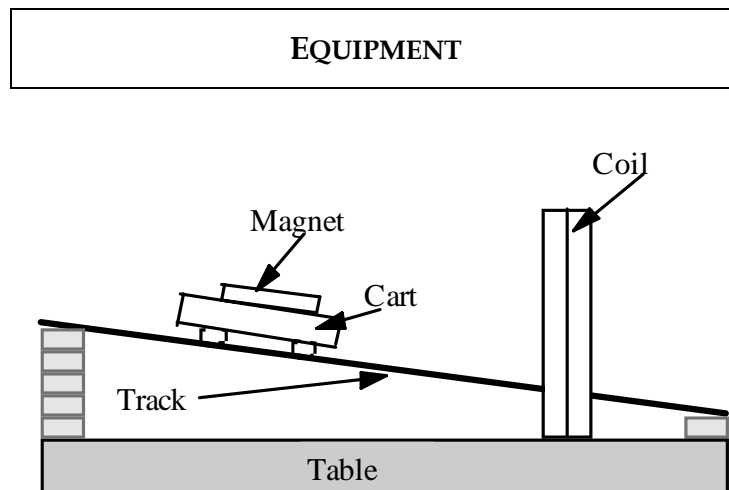
<b>CONCLUSION</b>
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Did your results agree with your predictions given the way the coil is wrapped and the way you hooked up your Faraday Probe? Explain any differences.



## PROBLEM #4: THE MAGNITUDE OF THE INDUCED POTENTIAL DIFFERENCE

To continue investigating how to improve the efficiency of electric generators, you decide to calculate how the induced potential difference across the ends of a coil of wire depends on the velocity with which a magnet is thrust through it. To check your calculation, you set up a laboratory model in which you can systematically vary the speed of the magnet. You mount a magnet on a cart and roll the cart down a ramp. At the end of the ramp, the cart passes through the center of a coil of wire. You can calculate the speed of the magnet as it goes through the coil from where it is released on the ramp.



You will have a large coil of 200 turns of wire, a magnet, a meter stick, a cart, and a track. The track can be raised at an incline using wooden blocks. You will also have a computer data acquisition system with an application written in LabVIEW™ to display potential difference as a function of time (see *Appendix E*).

PREDICTION

Calculate the induced potential difference in the coil as a function of the distance from the coil at which the cart is released and other quantities that are not changed. Make a graph of this function.

WARM-UP

Read Serway & Jewett: sections 22.1, 22.2, 23.1, 23.2, 23.3.

1. Draw a picture of the situation. Label important distances and kinematic quantities. Decide on an appropriate coordinate system and add it to your picture.
2. Use Faraday's Law to relate change of magnetic flux to the magnitude of the induced potential difference in the coil.
3. Draw a magnetic field map of a bar magnet. Draw the coil of wire on the magnetic field map. As the bar magnet passes through the coil, when is the flux change the strongest? What is the

relationship between the velocity of the bar magnet and the change of the magnetic flux through the coil? This tells you, qualitatively how the flux changes with time.

4. Look at the time rate change of the magnetic flux. How is it related to the velocity of the cart? It is important to note whether or not the quantities of interest vary with time or with the cross-sectional area of the coil.
5. What physics principles can you use to determine the velocity of the magnet as it passes through the coil to the starting position of the cart?
6. Write an equation giving the induced potential difference across the ends of the coil of wire as a function of the velocity of the magnet through the coil.
7. Write an expression for the velocity of the cart through the coil as a function of its starting distance from the coil. Substitute that into the equation for the induced emf.

### EXPLORATION

Before you begin exploring, consider what the signal displayed by the FaradayPROBE program will look like. Will you be able to tell by the signal when the cart has not passed through the ring, and when it has? Will the peaks be sharp or rounded? Will there be many peaks or only one? How will the signal look different from background noise? Draw on your experiences from problems 1 and 3 in this lab.

If necessary, disconnect the magnetic field probe from the LabPro interface. Plug the Faraday Probe into the LabPro interface. Attach the clips to the two ends of the coil and start the FaradayPROBE program.

Push the magnet through the coil to make sure that the apparatus is working properly and that you are getting appropriate potential difference graphs on the screen. How does the graph compare to your expectations?

Set up the track at an incline so that a rolling cart will go through the center of the coil. Try different angles to get the most reproducible situation in which you can change the velocity of the cart over the widest range without damaging the equipment. Be sure to have someone catch the cart when it reaches the end of the incline.

How often does the FaradayPROBE program update the screen? How long of a signal does it display? You may find that not all of the signal captured by the program is displayed; in that case, you will have to time your release of the cart to coincide with the part of the signal being displayed.

Securely attach a magnet to the cart and let it roll down the track while observing the potential difference displayed by the computer. Check that the release position does affect the potential difference graph on the computer. Try different time scales over which the computer makes the measurement. Are the differences large enough to measure reliably?

Does the orientation of the magnet matter? Try it.

Does the display of the potential difference as a function of time on the computer look as you expected? Be sure you can qualitatively explain the behavior that you see displayed. You might want to move the magnet by hand to see if your understanding is correct.

Try adding another magnet to the cart to increase the magnitude of the induced potential difference. Does it matter how the second magnet is oriented?

Develop a measurement plan to take the data you need to answer the question.

**MEASUREMENT**

Follow your measurement plan and record the maximum potential difference across the ends of the coil of wire as a function of the velocity of the magnet through the coil.

**ANALYSIS**

From your data construct a graph of maximum induced potential difference in the coil as a function of the distance from the coil at which the cart is released.

Add the graph of your prediction to the same plot and compare. You may need to normalize the graphs.

**CONCLUSION**

Did your results agree with your predictions? Explain any differences.

From the computer screen, make a sketch of the shape of the induced potential difference across the ends of the coil as a function of time for one pass of the magnet. Label each feature of the graph and indicate where the magnet is in the coil at that time and why the graph looks like it does at that time.

## PROBLEM #5: THE GENERATOR

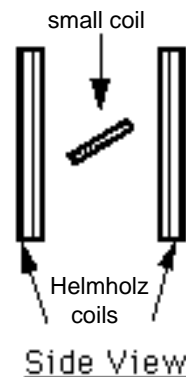
To begin investigating how to improve the efficiency of electric generators, your supervisor assigns you the task of building a working model of a generator from which it is easy to take measurements. Your model consists of Helmholtz coils to generate a well-defined magnetic field and a small coil of wire, mounted in between the Helmholtz coils, to generate the current. The small coil is mounted to a motor so that it spins at a uniform speed.

Before presenting the model to your supervisor you calculate the potential difference you expect and then take some measurements to make sure that the results correspond to your understanding of the situation.

### EQUIPMENT

The small coil sits between the Helmholtz coils, as shown to the right. The Helmholtz coils are connected to a power supply. The small coil has 4000 turns of wire, and can be rotated by a motor. The Cenco supply's 0-5volt is used to power the small coil.

You will have a Hall probe, a DMM, and a meterstick. You will also have a computer data acquisition system with an application written in LabVIEW™ to display potential difference as a function of time (see *Appendix E - Measuring Time-Varying Voltage*).



### PREDICTION

Calculate the potential difference produced by a coil of wire spinning in a uniform magnetic field as a function of its angular speed.

### WARM-UP

Read Serway & Jewett: sections 22.7 (and example 22.6), 23.1, 23.2, 23.3.

1. Draw a picture of the equipment labeling the direction of the magnetic field and the orientation of the small coil. Choose a coordinate system on the small coil.
2. Use Faraday's Law to relate the changing magnetic flux through the coil to the potential difference across the ends of the coil of wire. The changing magnetic flux is caused by the angular speed of the coil.
3. Draw a diagram showing only the small coil, a vector giving the direction of the magnetic field, and the area vector for the coil.
4. Write an equation for the magnetic flux through the small coil when it is stationary and at some angle to the magnetic field.

As the small coil is rotated, how does the angle its area vector makes with the magnetic field vary with time? That variation is related to its angular speed.

5. Write an expression for the change in magnetic flux through the small coil as it turns.

### EXPLORATION



**WARNING:** You will be working with equipment that generates large electric currents. Improper use can cause painful burns. **To avoid danger, the power should be turned OFF and you should WAIT at least one minute before any wires are disconnected from or connected to the power supply.**

You will want as large a magnetic field as you can produce safely with the equipment available. Develop a plan for measuring the magnetic field using the Hall probe. Where will you want to measure the magnetic field? Over what region do you need the magnetic field to be reasonably constant? Check to see if it is. Decide whether you should set the amplifier to high or low sensitivity.

Before connecting the motor to a power supply (or batteries), disconnect the Hall probe from the LabPro interface (if necessary). Plug the Faraday Probe into the LabPro interface and attach the clips to the two ends of the small coil. The ends of the small coil are attached to terminals (small wires sticking up) located near the bearings on opposite ends of the axle about which the coil spins. Use the time varying voltage LabVIEW™ application to get an on-screen display of the small coil's potential difference versus time.

With the Helmholtz coils generating a magnetic field, align the small coil such that its area vector is parallel to that magnetic field. What does the display of potential difference versus time read? Is this what you expected? Repeat by moving the small coil so that its area vector is perpendicular to the field.

Now connect the motor to a battery (or 0-5 V DC variable voltage on a power supply) and note the appearance of the potential difference versus time display. Determine how you will measure the rotational period of and the potential difference across the small coil. How can you determine the angular speed of the coil from its rotational period?

Try changing the motor's speed by connecting it to a different number of batteries or increasing the power supply voltage. How does changing the speed affect the display?

Determine the range of potential differences and rotational periods that you will use for your measurements so that you can set the scale for your graph of maximum potential difference as a function of rotational period.

### MEASUREMENT

Note that the area of the small coil enclosed by the inner loops of wire is smaller than that enclosed by the outer loops of wire. Decide how to determine the effective area for the coil.

Measure the strength of the magnetic field produced by the Helmholtz coils in the region of interest.

From the computer display of potential difference as a function of time, measure the maximum potential difference induced in the small coil and the rotational period of the small coil (see *Appendix E*).

Do several trials, rotating the coil at a different constant speed for each. How can you check your computer display to ensure that the coil is rotating at constant speed?

<b>ANALYSIS</b>
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Determine the equation that best represents your collected data. What physical quantities do the constants in your equation represent? What do the variables in your equation represent?

<b>CONCLUSION</b>
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What is the potential difference induced in a coil spinning in a uniform magnetic field? Did your measured potential difference agree with the predicted potential difference? Did the period of the signal agree with your predictions? If not, why not? What are the limitations on the accuracy of your measurements and analysis?

How does the amount of potential difference produced by the generator depend on the angular speed at which the generator rotates?

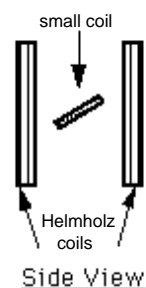
## PROBLEM #6: TIME-VARYING MAGNETIC FIELDS

You are working for a research team at the University of Minnesota that is developing a new method to electronically detect cancer cells in the lining of a patient's intestine. The patient swallows a small probe, which works its way through the intestine gathering data. Naturally you can't have the probe connected to external wires and you don't want to use a battery inside the person. Instead you plan to power the probe by using an external time-varying magnetic field and a small pick-up coil of wire inside the probe. Your boss is concerned that it won't work because you have no control over the orientation of the probe within the patient's intestine. Specifically, you can't control the angle dependence between the coil and the magnetic field. You have been asked to investigate the magnitude of this problem. You decide to study how the induced potential difference depends on the angle the coil makes with the external magnetic field.

### EQUIPMENT

A small "pick-up coil" is mounted between Helmholtz coils, as shown to the right. The small coil has 4000 turns of wire.

A function generator outputs an electrical current, which changes with time as a sine function. When the Helmholtz coils are connected to a function generator, an alternating current goes through the coils. *Use only frequencies of less than 100 Hz.*



You will have a DMM, a magnetic compass, a meter stick, and a protractor. You will also have a computer data acquisition system with an application written in LabVIEW™ to display potential difference as a function of time (see *Appendix E - Measuring Time-Varying Voltage*).

### PREDICTION

Calculate the potential difference across the pick-up coil, for a magnetic field changing with a known period, as a function of the angle the coil makes with the magnetic field. From this expression, make a graph of the maximum potential difference as a function of the angle.

### WARM-UP

Read Serway & Jewett: sections 22.7 (and example 22.6), 23.1, 23.2, 23.3.

1. Draw a picture of the equipment, labeling the direction of the magnetic field and the orientation of the small coil. Choose a coordinate system on the small coil.
2. Use Faraday's Law to relate the changing magnetic flux through the coil to the potential difference across the ends of the coil of wire. The changing magnetic flux is caused by the angular speed of the coil.
3. Draw a diagram showing only the small coil, a vector giving the direction of the magnetic field, and the area vector for the coil.

4. Write an equation for the magnetic flux through the small coil when it is stationary and at some angle to the magnetic field.
5. Write an equation for the magnetic field produced by the current in the Helmholtz coils.
6. Write an expression for the change in magnetic flux through the small coil, as the current changes with time as a sine function.

### EXPLORATION

Use the function generator to drive a low frequency alternating current through the large parallel coils of the Helmholtz coils:

- Set the function generator to create a sinusoidal voltage.
- Use the output labeled LO $\Omega$  on the function generator to drive the current through the coils.
- Connect the Helmholtz coils in series so that they carry the same current. Should the current go in the same direction or the opposite direction in the two parallel coils to give the most uniform magnetic field between them?

Set the frequency from the function generator to less than 1 Hertz. If you placed a compass in the magnetic field near the pick up coil, what would you expect to see? Try it. Slowly increase the frequency of the current in the Helmholtz coils. What happens to the compass needle? Is this consistent with what you expected?

Orient the small coil so that the largest magnetic flux passes through it. Attach the DMM to the small coil to read the potential difference across it. Set the DMM to read AC voltage. Slowly change the orientation of the small coil to get the maximum potential difference.

Adjust the amplitude of the signal generator to give the maximum reading on the DMM. At the lowest frequency compare the AC voltage reading to the DC voltage reading. Slowly increase the frequency and observe the results for both AC and DC settings. Decide on the best frequency to use.

Use a Hall probe and the LabVIEW™ application to determine how the magnetic field between the Helmholtz coils varies as a function of time at the frequency you have selected. Note how much time it takes for the computer display to react to any adjustment you make. Try different data sampling times on computer display and select the best one for your situation.

Adjust the amplitude of the function generator to give a magnetic field reading that looks like a sine (or cosine) function. Select the best amplitude for your measurements. How does the magnetic field period on the computer display compare to the frequency of the function generator? What happens to the amplitude of the magnetic field as you change the frequency of the function generator?

Select a range of angles to use in your measurement and note the range of magnetic field amplitudes you expect for the signal generator frequency and amplitude you have chosen to use.

The magnetic field is just the Hall probe reading (a voltage) times a calibration constant. Determine this calibration constant.



**MEASUREMENT**

For a fixed function generator output, measure how the potential difference across the pick up coil varies with time as a function of its angle with the magnetic field. Take enough data to convince others of your findings.

**ANALYSIS**

Using your measurements, graph the potential difference across the pick up coil as a function of time, for a fixed function generator output. What is the period of the potential difference? The frequency? How does this behavior change as the angle between the pick up coil and the magnetic field changes?

How does the time structure of the potential difference across the pick up coil compare to the output of the function generator?

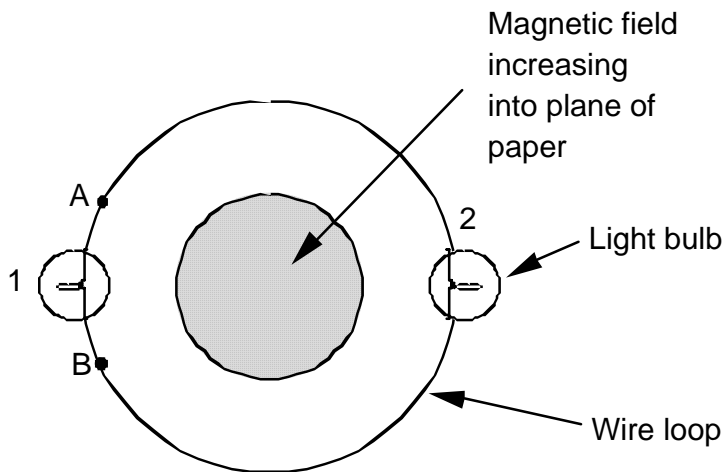
Graph the maximum potential difference across the pick up coil as a function of the angle the coil's area vector makes with the magnetic field.

**CONCLUSION**

Does the time variation of the potential difference across the pick up coil agree with your prediction? If not, why?

## ☑ CHECK YOUR UNDERSTANDING

1. A long solenoid, with the axis perpendicular to the plane of the paper, carries a current that continually increases with time. A loop of wire with two light bulbs is connected around the solenoid. What is the direction of the induced current in the wire loop? Compare the brightness of light bulbs 1 and 2.



If a wire was connected from point A to point B, compare the brightness of bulbs 1 and 2.

2. A coil with 50 turns, a diameter of 8 cm, and a resistance of  $9 \Omega$  is placed perpendicular to a uniform magnetic field of 2.0 T. The magnetic field suddenly reverses direction. What is the total charge that passes through the coil?

# PHYSICS 1202 LABORATORY REPORT

## Laboratory VI

Name and ID#: \_\_\_\_\_

Date performed: \_\_\_\_\_ Day/Time section meets: \_\_\_\_\_

Lab Partners' Names: \_\_\_\_\_

\_\_\_\_\_

Problem # and Title: \_\_\_\_\_

Lab Instructor's Initials: \_\_\_\_\_

Grading Checklist	Points
<b>LABORATORY JOURNAL:</b>	
<b>PREDICTIONS</b> (individual predictions and warm-up completed in journal before each lab session)	
<b>LAB PROCEDURE</b> (measurement plan recorded in journal, tables and graphs made in journal as data is collected, observations written in journal)	
<b>PROBLEM REPORT:*</b>	
<b>ORGANIZATION</b> (clear and readable; logical progression from problem statement through conclusions; pictures provided where necessary; correct grammar and spelling; section headings provided; physics stated correctly)	
<b>DATA AND DATA TABLES</b> (clear and readable; units and assigned uncertainties clearly stated)	
<b>RESULTS</b> (results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; physics stated correctly)	
<b>CONCLUSIONS</b> (comparison to prediction & theory discussed with physics stated correctly ; possible sources of uncertainties identified; attention called to experimental problems)	
<b>TOTAL</b> (incorrect or missing statement of physics will result in a maximum of 60% of the total points achieved; incorrect grammar or spelling will result in a maximum of 70% of the total points achieved)	
<b>BONUS POINTS FOR TEAMWORK</b> (as specified by course policy)	

\* An "R" in the points column means to rewrite that section only and return it to your lab instructor within two days of the return of the report to you.

