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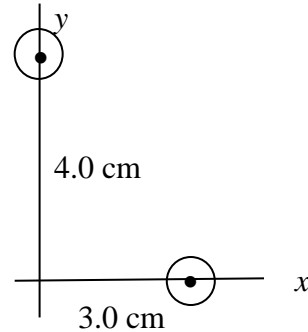
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Pre-Lab 7: Magnetic Fields

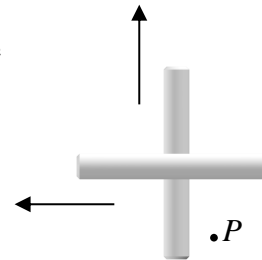
Pre-Lab Due 6/1

The pre-lab questions are to be answered using the provided template. Only the pre-lab work needs to be digitized into PDF format and uploaded to gradescope.com by the due date.

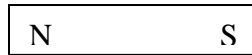
1. Two long straight wires carry currents of 12.4 A in the same direction (out of the page of the drawing). Find the magnitude and direction of the magnetic field at the origin.



2. Two long perpendicular wires carry identical currents in the plane of the page, as shown. What is the direction of the magnetic field at point P ? Explain your answer.



3. (a) Sketch the external field lines that represent the magnetic field of a bar magnet. Draw ten or so small compasses (show N/S) spaced around the magnet, showing where they'll point.



(b) Sketch the external field lines that represent the magnetic field of two bar magnets placed end-to-end.

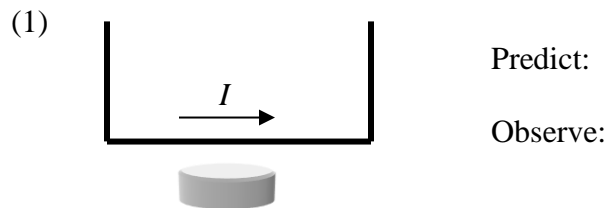


Lab 7: Magnetic Fields

I. Magnetic Field of a Straight Wire

In this activity, you will use a U-shaped wire that hangs from support wires on a wooden dowel. The hanging wire is designed to swing freely, although this lab will not be swinging them. Do not yet connect the leads to the battery. You will predict the outcome of a situation before you connect the battery, and then you will perform the experiment to check your predictions. **Connect the battery only for a moment to make your observations; do not leave the battery connected once you have made your observations.** Be sure you understand the relationship between the connections to the battery terminals and the direction of current flow in the wire.

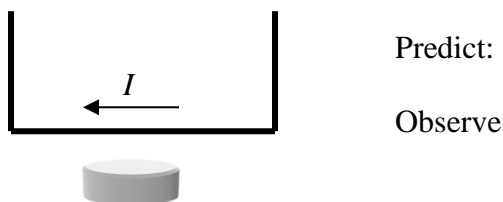
Hold the compass in a horizontal plane just below the horizontal part of the U-shaped wire. Predict the direction that the compass needle will point after the battery is connected.



On the above figure, sketch the pattern of magnetic field lines due to the current in the horizontal part of the wire. Indicate the direction of the magnetic field at the center of the compass. Discuss the relationship between the magnetic field direction at the location of the compass and the direction of the compass needle.

Does the Earth's magnetic field have an effect on your observations? Change the orientation of the apparatus on the table so that you change the initial direction of the compass relative to the wire (when no current flows in the wire.) Does the current have the same effect on the compass in this different orientation? How great is the influence of the Earth's field compared to the wire's field?

(2) Now reverse the direction of the current.



Does your prediction agree with your observation? How does this activity change if your horizontal wire is aligned east-west?

Lab instructor check point _____

II. Magnetic Field of a Current Loop and the Earth's Field

In this activity, you will study the magnetic field produced by a circular loop of current. You will also determine the magnitude of the horizontal component of the Earth's magnetic field.

The magnetic field at the center of a coil with radius R of N turns of wire carrying current I is:

$$B = \frac{\mu_0 NI}{2R} \quad (1)$$

When a compass is placed near the loop, the direction of the compass needle will indicate the direction of the total magnetic field – the vector sum of the field of the loop and the field of the Earth. We will align the loop so that the Earth's magnetic field is perpendicular to the axis of the loop. The resulting magnetic fields have directions as indicated in Figure 1. The angle θ is determined by the direction of the compass needle and gives the angle of the total field (relative to loop and Earth fields.)

$$\tan \theta = \frac{B_{\text{loop}}}{B_{\text{Earth}}} \quad (2)$$

Figure 1 shows a view looking down on the loop from above. Only the horizontal component of the Earth's field contributes to the total field as we're measuring it. (Why is that?)

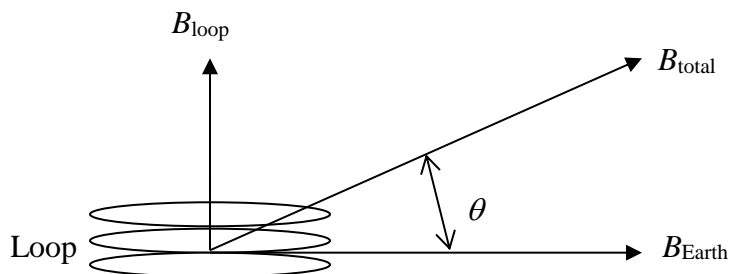


Figure 1

PROCEDURE: Your coil is connected to a table power connection set at (about) 5 V. The double pole switch allows you to switch the direction the current flows through the coil. The variable resistor allows you to control the amount of current that flows through the coil. The multimeter will tell you the current (in the coil.)

If you have any doubts about the connections, check with your TA.

CAUTION: To keep the loop from overheating, place the switch in the neutral (center, straight up) position when you are not making any measurements.

Place the compass at the center of the loop. When there is no current flowing, turn the table until the loop's axis is perpendicular to the direction of the Earth's magnetic field, as in Figure 1.

Adjust the current in the loop until the compass needle makes an angle of 30° with its original direction. Record the current. Repeat for angles of 45° and 60° , and then reverse the direction of the current and repeat for the same deflections but in the opposite direction.

For each angle measurement, calculate the magnetic field of the loop and then calculate the value of the Earth's field. For each angle, draw a vector diagram to approximate scale showing B_{loop} , B_{earth} , and θ . From your measurements and calculations, calculate the average value of the Earth's field. Remember that this is only the horizontal component.

Questions:

1) How does your measured/calculated value for the Earth's field compare to the (estimated or approximate) actual value. (What *is* the actual value?)

2) The dip angle in Oregon is nearly 70° . Assuming your calculate Earth's field is only the horizontal component, what's the magnitude of the total Earth's field (based on your calculated value)?

3) You computed the magnetic field of the center of the loop, and you placed the compass at the center of the loop. How does the length of the compass needle affect your results? That is, the center of the compass could be on the axis of the loop, but the needle tip is not.

Lab instructor check point _____

Data Sheet – Magnetic Field of a Current Carrying Loop

Name _____ Partner(s) _____

Values for the wire loop: $N =$ _____ turns $R =$ _____ m

θ	30°	45°	60°
I (A)			
B_{loop} (T)			
B_{Earth} (T)			
Vector diagram			

θ	-30°	-45°	-60°
I (A)			
B_{loop} (T)			
B_{Earth} (T)			
Vector diagram			

Average value of $B_{\text{Earth}} =$ _____

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