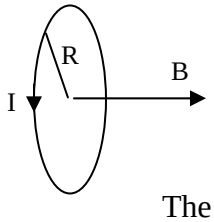
Magnetic Field Due to a Circular Current Loop

Purpose: 1. To measure the magnetic field at the center of a circular current loop.
2. To determine the magnetic permeability constant.

Equipment: DC power supply (0-3A), magnetic field sensor, lab pro, support rod, clamps, ammeter, circular coil of wire, computer, connecting wires, meter stick

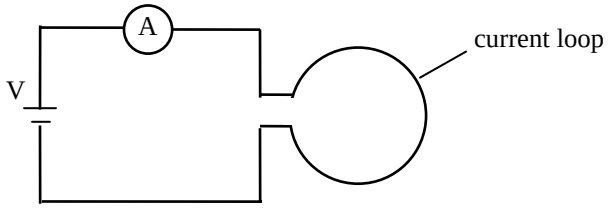
Introduction: As shown in class, the magnetic field, B, at the center of a circular current loop of radius R is given by



$$B = \frac{N \mu_o I}{2 R}$$

Where I is the current in the loop, μ_o is the magnetic permeability, and N is the number of turns of wire

The direction of the magnetic field is perpendicular to the plane of the loop and in a direction given by the right hand rule as shown in the figure. A Hall effect probe will be used to measure the strength of the magnetic field (B) at the center of the loop. The probe converts the strength of the magnetic field into a voltage that can be measured using the computer.



Procedure:

1. Measure the diameter of the coil. Notice that one side of the metal frame has been cut away to facilitate this measurement. Think carefully about which diameter you actually want to measure. Determine the center of the coil and, using a clamp and support rod, position the magnetic sensor so that the white circular spot is at the center of the coil and facing perpendicular to the axis of the loop. (The sensor determines the component of the magnetic field at this point that is perpendicular to the white spot.)
2. Set the switch on the magnetic sensor box to the high amplification setting. Connect the lab pro to the computer and magnetic probe to CH 1 port on lab pro. Turn on the computer and double click on the **Physics Apps** icon if this window is not already opened. Double click on the **Logger Pro** icon to start this program running. Choose **Open** from the menu bar at the top of the screen and select the **Electricity and Magnetism** folder by double clicking. Double click on the file named **Magloop** to set up the computer for today's lab. You should see a graph of Magnetic Field vs Time displayed.
3. You will need to take a background reading of the magnetic field (due to the earth and other magnetic influences; can you think of some other magnetic influences?) with no current flowing through the coil. With the power supply disconnected, click the **collect** button to take a reading of the background magnetic field. Record the average value observed (in μT). What is the direction of the background field?

4. Set up the circuit to supply current to the coil by putting an ammeter in series with the coil as shown. Use the outermost connections on the coil so that 70 turns of wire are used. This will give the maximum magnetic field for the least current. Have your instructor verify that you have the circuit properly wired and that the ammeter has the appropriate settings. The maximum current you will be running through the coil is 0.5 amp.
5. After your circuit has been okayed by your instructor, adjust the power supply to provide a current of 0.50 amps through the coil. Record the current reading on your ammeter and then take readings of the magnetic field with the computer by clicking the **collect** key. (If the readings for magnetic field are negative, reverse the direction of the current.) Adjust the orientation of the probe to obtain the largest possible reading for the magnetic field for this current. Keep this alignment throughout the entire experiment. Record the average value of the magnetic field. Repeat for currents of 0.45, 0.40, ….0.05 amp in steps of 0.05 amp.
6. Set up a data table in your lab report with columns for current, measured magnetic field, and magnetic field of the coil. Make a sketch showing the direction of the background magnetic field and the field due to the coil. From this sketch determine whether you should add or subtract the background field from your measured magnetic field to obtain the field due to the coil. Carefully explain your logic.
7. Open the **Graphical Analysis** program by clicking on its icon in the **Physics Apps** window. Enter your data for current and the magnetic field due to the coil so that the current is displayed along the x-axis. Put appropriate labels and units on the graph. Hopefully, your graph should indicate a linear relationship between this magnetic field and the current. Let your instructor verify that the graph has the proper appearance. Obtain a linear fit to the data by selecting **Analyze/Curve Fit** and choosing the appropriate fitting function. Record the slope of your graph and obtain a printout of the graph and data table by selecting **Print** from the **File** menu.
8. Referring to the equation for magnetic field due to a coil of wire given in the introduction part of the lab sheet, explain why you would expect the graph of B vs I to have a linear appearance. Again referring to the equation, identify what the slope of the graph should correspond to. Using your value of the slope, find the value of the magnetic permeability constant and compare with the accepted value. Be careful with units in your calculation.