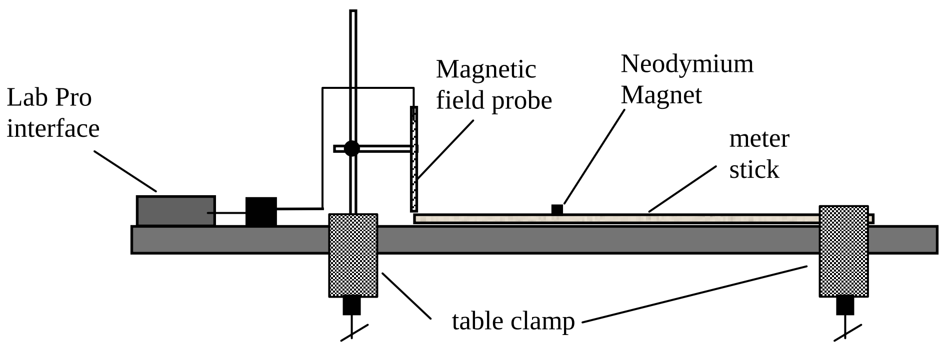
Magnetic Field Due to a Neodymium Magnet

Purpose: 1. To measure and graph the magnetic field as a function of distance from the center of a neodymium magnet.
2. To determine how closely the field due to the magnet approximates that of a magnetic dipole.

Equipment: Magnetic field sensor, lab pro interface, support rod, clamp, neodymium magnet, computer, meter stick.

Introduction: As discussed in class, the magnetic field *at distant points* along the axis of a magnetic dipole varies as $1/x^3$ where x is the distance from the center of the dipole. The neodymium magnet should create a field that closely approximates that of a magnetic dipole. By making a plot of magnetic field strength, B, versus distance, x, along the axis of the magnet and fitting the data to an inverse power law ($B = Ax^{-n}$), the comparison between an ideal dipole and the neodymium magnet should be apparent.



Procedure:

1. Set the switch on the magnetic sensor box to the high amplification setting. Place the magnetic field probe so that the white dot faces perpendicular to the long dimension of the meterstick and is at the right height to measure the magnetic field along the axis of the neodymium magnet. Clamp the meterstick to the table and position the meterstick so that the zero mark is aligned with the white dot. Keep in mind that the magnetic probe measures the component of the magnetic field perpendicular to the white dot.
2. Connect the lab pro to the computer and the magnetic field sensor to CH1 port on the lab pro. Check that magnetic field sensor is set for high sensitivity. Load the **Logger Pro** software and choose **File/Open**. Double click on the **Electricity and Magnetism** folder and open the file called **Neod dipole**. You should see a graph of magnetic field, B, vs time. Note the scale and units for both axes.
3. With all magnetic materials safely away from the sensor, take a background reading to determine the earth's magnetic field and any stray laboratory magnetism at the location of the sensor. Click on **collect** button to begin taking data. The data rate should be 20 Hz and the time duration around 2 s. With the mouse, select the data for the entire graph and choose **Analyze/Statistics** to obtain the mean value for the background magnetic field. Record this value.
4. Set up a data column for calculating the Net Magnetic Field by choosing **Data/New Calculated Column.** Name the new column *Net Magnetic Field* and enter appropriate units (mT). In the

Equation box enter the equation for the new column (Magnetic field minus the mean background reading obtained in part 3). By subtracting off this value from each magnetic field reading you should be able to graph just the field due to your magnet alone.

5. Now select **Experiment/Data Collection** and click on the pull down **Mode** menu and choose "Events with Entry." Type in "Distance" in the **Column Name** box and "cm" in the **Units** box. Click **Done** and then set up the graph for plotting net magnetic field vs distance. Choose a horizontal range of 0 to 20 cm and a vertical range of 0 to 0.4 mT. Position the center of the neodymium magnet at a distance of 8.0 cm from the white dot on the magnetic probe. Using a small piece of clay or tape, align the axis of the magnet along the meterstick and face the magnet so that the readings you obtain in what follows are positive rather than negative. To start the computer measurement of the magnetic field, click on **Collect.** You will see the values of B in a small area below the graph. Click on **Keep** and then type "8.0" from the keyboard in the "**Distance**" box. A reading of the magnetic field will automatically be recorded along with the 8.0 cm.
6. Repeat by taking readings every 0.5 cm out to 18.0 cm. Observe the resulting graph. The data should form a smooth curve.
7. Choose **Analyze/Curve Fit** and select **Power** for the type of function to be fitted to your data. Select **Try Fit**. How well does the fitting function appear to fit your data curve? If the fit looks good, click **OK** and record the value of the exponent. How does this exponent compare with that expected for a magnetic dipole? Does your magnet approximate an ideal dipole?
8. Determine the magnetic dipole moment of your magnet by comparing your computer generated fitting function with the equation for the magnetic field due to a dipole at distant points.
9. If we imagine an equivalent magnetic field created by a current loop with the same radius as the neodymium magnet, then the magnetic moment of the magnet would be the same as for the current loop. Find the current associated with this equivalent loop of current. Assume the radius of the current loop to be the same as the radius of the magnet.
10. Repeat steps 3-9 for the same magnet but with the poles reversed.
11. Discuss what is meant by distant points from the magnet (as mentioned in the introduction above). How well do the distances in your experiment satisfy this criteria? Be quantitative in your discussion.