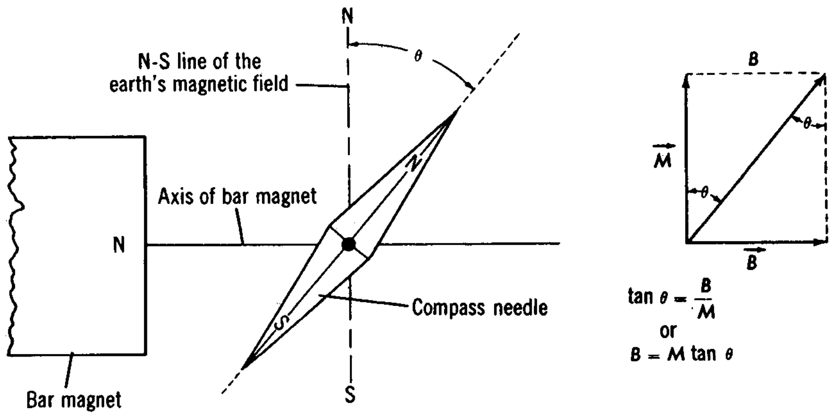
Name **Section #**

Strength of a Magnetic Field

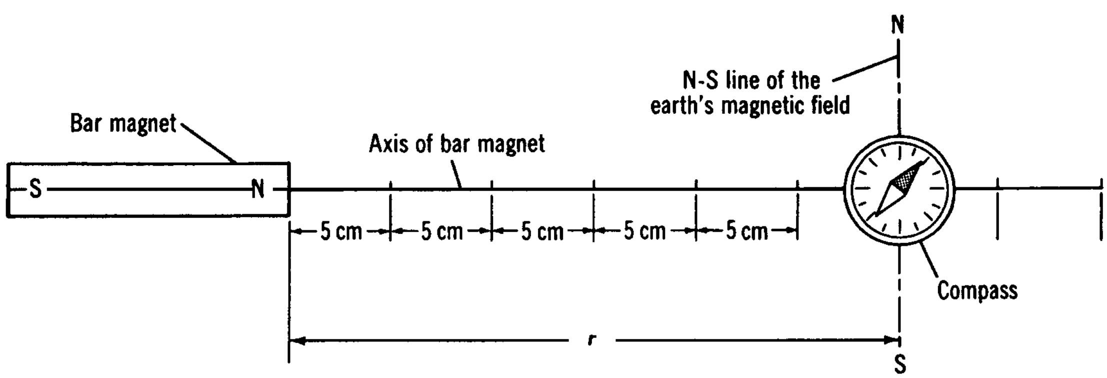
Purpose

You will determine whether the magnetic field strength, B of a bar magnet along its longitudinal axis varies inversely with the square of the distance, r from either pole.



Theory

The bar magnet's field intensity, B at any location can be determined by comparing it with that of the earth's magnetic field, M at the same location by orienting the magnet so that both fields are perpendicular to each other. If a compass is placed at the point to be examined, it will experience two mutually perpendicular deflecting forces produced by B and by M. Under the action of the two fields, B and M, the compass needle assumes an equilibrium position along the resultant of the two fields. As shown by the above diagram, the compass's deflection $\theta = \tan^{-1}\left(\frac{B}{M}\right)$, or $B = M\tan\theta$. The horizontal component of the earth's magnet field, M is approximately 2.0×10^{-5} T at Brooklyn Technical High School.



Procedure

Rule a line length-wise down the center of a long sheet of paper about 50 centimeters long. If necessary two sheets of paper may be taped together to make one long sheet. This line will mark the axis of the bar magnet. Construct a perpendicular to this line approximately 10 cm from the edge of the page, label its ends N and S as shown in the picture above. Subdivide the long line on your paper in units of 5 cm, starting from the *N-S* line until you have reached 40 cm. Place your compass on the intersection of the two lines, orient it so that the *North* and *South* markings on its case lines up with *N-S* line, and then tape it to the paper. Remove all magnets from the table. Rotate the paper with the attached compass until the *N-S* line of the paper coincides with the direction of the compass needle. Fix the paper in this position by fastening it to the table with the tape.

Place the bar magnet on the axial line, 40 cm from the *N-S* line, with the north pole facing the compass, and measure the compass needle's deflection, θ from north. You may find it necessary to gently tap the compass with a pencil to overcome the friction between the needle and its mounting. Record the deflection in the data table in the row corresponding to 40 cm and fill in all the columns corresponding to that row. Move the bar magnet closer to the compass in increments of 5 cm repeating the above procedure until you have completed all the entries in the data table. Plot a graph with $\tan\theta$ as the ordinate versus $\frac{1}{d^2}$ as the abscissa and draw a best-fit line.

Distance, d (m)	θ (degrees)	$\tan\theta$	$\frac{1}{d^2}$
0.40			
0.35			
0.30			
0.25			
0.20			
0.15			
0.10			
0.05			

Questions

Does the magnetic field intensity, B along the axis of the magnet vary inversely with the square of the distance from its poles? Justify your answer by discussing the relationship between B and $\tan\theta$, and also whether the best-fit line adequately represents the trend of your data.

For what value of θ is the field strength of the bar magnet equal to that of the horizontal component of the earth's magnetic field?

At what distance from the north pole of the magnet are the two field intensities equal?

Assuming the horizontal component of the earth's magnet field, M to be 2.0×10^{-5} T at your locale, compute the value of B at distances along the axis of 10, 20, and 30 cm from the bar magnet's north pole.

Supplementary Activity

Repeat this experiment for the axis at right angles to the magnet through its center. At every point on this axis, the field is parallel to the magnet.

Make a graph showing how the field strength varies with the distance from the center of the magnet by plotting $\tan\theta$ versus $\frac{1}{d}$.

Graph of $\tan\theta$ versus $\frac{1}{d^2}$ along a Bar Magnet's Longitudinal Axis

Graph of $\tan\theta$ versus $\frac{1}{d}$ Perpendicular to the Bar Magnet through its Center