Magnetic Dipoles

Recorder___________________________________ Manager___________________________________

Skeptic___________________________________ Energizer___________________________________

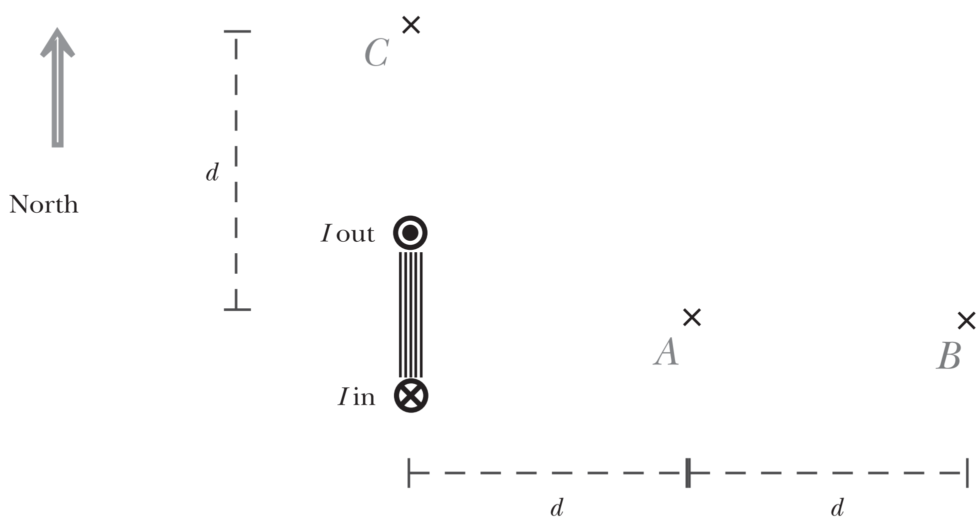
1 Measure the magnetic field near a coil of wire; compare to theoretical predictions

Take an insulated wire 1 or 2 meters long and wrap a coil of about 20 turns loosely around two fingers. Twist the ends around the coil to hold it together, and remove the coil from your fingers. Attach clip leads so you can connect the coil to one battery. Orient the coil perpendicular to the table, with its axis pointing East-West, as shown in the diagram below. Note that electrons leave the negative pole of the battery, so "conventional current" leaves the positive pole of the battery.

Place a compass at location *A*, a distance *d* from the coil where the deflection of the compass is 50°. Measure the distance *d* carefully and record the result below. Now measure compass deflections at *B* and *C*.
Caution: Don't leave this "short" circuit connected for a long time. Disconnect after measuring deflections.

(1.a) At each location (A, B, C), draw and label two arrows:

- *Direction of compass needle* (show deflections accurately)
- *Direction and relative magnitude* of the magnetic field due to the coil



(1.b) Record these values:

number of turns in coil	
coil radius	
distance *d* (50° deflection)	
compass deflection at *A*	
compass deflection at *B*	
compass deflection at *C*	

(1.c) Is the pattern of magnetic field you observe characteristic of a dipole?

Make sure you have shown the compass needle deflection and magnetic field at A, B, and C above.

Remember that the tail of an electric or magnetic field arrow must be at the observation location.

(1.d) Calculate the magnitude of the conventional current running in the coil. Show your work. Remember that the magnetic field along the axis of a current-carrying coil with N turns, not too near the coil, is approximately $|\vec{B}_{coil}| \approx N\frac{\mu_0}{4\pi}\frac{2\mu}{z^3}$, where the magnetic dipole moment is $\mu = IA$, and A is the area of the coil.

Check with a neighboring group, then both groups check with instructor.
The TA will look for compass deflections and fields on your diagram on page 1.

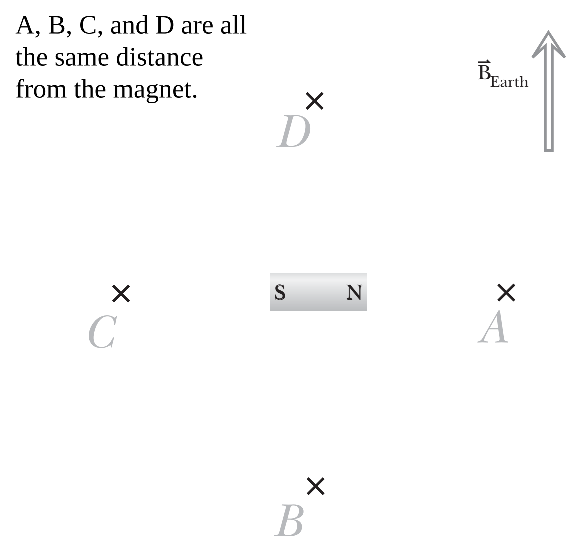
2 Measure the magnetic field near a bar magnet

Pattern of magnetic field near a bar magnet

Use a compass to map the magnetic field around a bar magnet at equal distances. It is easier to move the magnet than the compass; you may need to think a little about how to do this. At each compass location, draw *and label* two arrows:

- The direction the compass needle points
- The direction and relative magnitude of the magnetic field due to the bar magnet

(2.a) Look at the pattern of magnetic field you have recorded. What does it look like?



Distance dependence of magnetic field of a bar magnet

(2.b) Carefully align the magnet and compass as in position A in the diagram above. Find the distance at which the compass deflection is 70°, and record this distance below.

center-to-center distance d_{70} for $70°$ deflection	
calculated magnetic field of magnet at d_{70}	
deflection at $2 \cdot d_{70}$	
calculated magnetic field of magnet at $2 \cdot d_{70}$	
distance dependence: $B \propto d^n$; n = ? (see note below; show your work)	

Remember that if $B = k(d^n)$, then $\frac{B_{2d}}{B_d} = \frac{k(2d)^n}{k(d)^n} = \frac{k2^n d^n}{kd^n} = 2^n$, and $\ln\left(\frac{B_{2d}}{B_d}\right) = \ln(2^n) = n\ln 2$

Magnetic dipole moment of bar magnet

(2.c) Using data from your measurement at $70°$ deflection above, calculate the approximate magnetic dipole moment of your bar magnet. Show your calculations, which should be organized clearly and legibly. Remember that the magnetic field along the axis of a bar magnet, not too near the magnet, is approximately $|\vec{B}_{magnet}| \approx \frac{\mu_0}{4\pi}\frac{2\mu}{z^3}$, where z is measured from the center of the bar magnet.

Measured magnetic dipole moment of the bar magnet______________________________________

Mass of the bar magnet____

(2.d) In the textbook you saw that in a simple model of an atom with an unpaired electron, the atom had a magnetic dipole moment of $1\times10^{-23}\ \text{A}\cdot\text{m}^2$. If we assume that in your bar magnet all the atoms are aligned, what would you predict from this simple model for the magnetic dipole moment of your bar magnet? (The atomic mass of iron, the principal constituent of these magnets, is 56 grams per mole.)

Theoretical prediction for the magnetic dipole moment of the bar magnet__________________________

Is there rough agreement between your measurement and the theoretical prediction?_________________

Make sure that everyone in the group agrees on the results.
Record in WebAssign the magnetic dipole moment and mass of the magnet.
You will need this information later in the course.
Check with another group, then give to instructor to grade.
The TA will look for compass deflections and fields on your diagram on page 2.