Physics PreLab 212-4

Do Magnets Grow on Trees?

Name ______________________________

Section ____________ **Date** ____________

Where little magnets come from

In Lab 212-2 you investigated the nature of the *electric field*. To do this, you mapped the *equipotential* lines between electrodes. The electric field was determined by drawing lines perpendicular to those equipotentials. Some equipotentials and field lines looked like those in Figure 1.

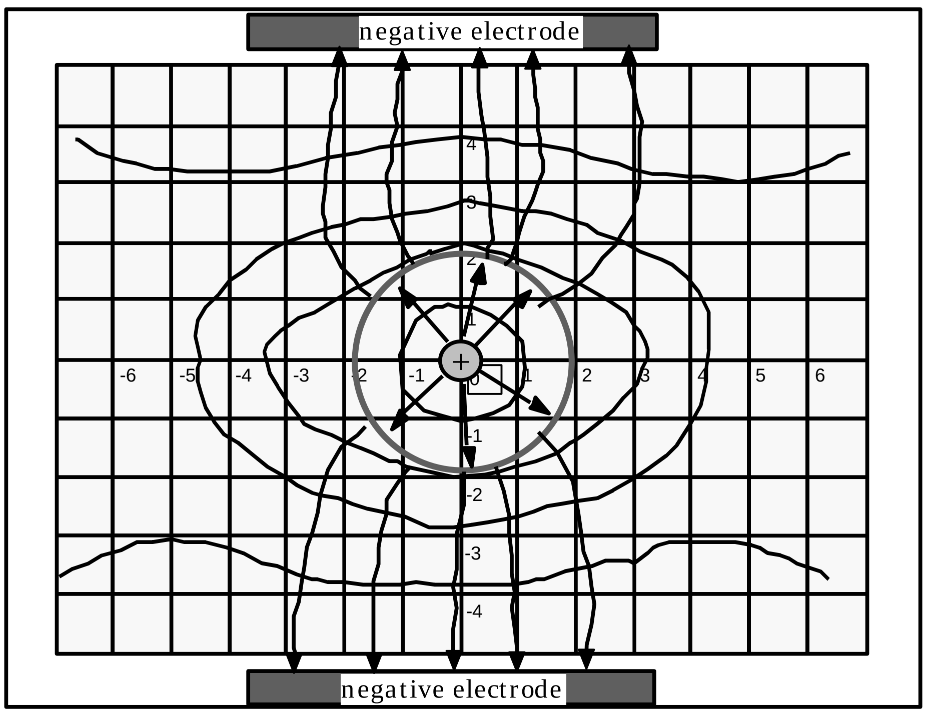

Figure 1. Equipotentials and their associated field lines

The SI unit of *electric potential* is the "Volt," which is really the potential energy per unit charge, or J/C. This means if we put a 3.0 Coulomb charge at a spot which measures 6.0 Volts, the charge would have a total of 18 J of potential energy, relative to the point where zero voltage (and thus zero potential energy) had been defined.

In turn, the electric field specifies the value and direction of a force that would be felt by a charge. Recall that the units of the electric field are N/C. So, for a 3.0 Coulomb charge in a field whose magnitude is 4.0 N/C, the force on the charge is 12 N.

For the magnetic force, things are rather different. For instance, no magnetic "monopoles" have ever been found. This means there are no isolated "north-poled" objects about. While isolated electric charges are the origin of electric fields, *charges in motion* are the generators of magnetic fields. To create magnetic fields you may then ask, "Where are the charges in motion?" This answer will take on two forms: one microscopic, the other macroscopic.

On the macroscopic level, one finds that a current in a wire produces a magnetic field. In next week's lab, you will probe the region around a wire to see if there is indeed any magnetic field caused by moving charges inside the wire.

At the atomic scale, electrons inside a material are buzzing around. They possess an important property physicists call "spin," suggesting something like the spinning motion of a top. Modern physics teaches us that this picture is not accurate; but "spinning" electrons do possess angular momenta and do act like individual charges in motion, which means they produce magnetic fields even if they are not zooming through space. Arrange them in bulk materials so that the axes of the "spinning" electrons point in the same direction, and you will get an appreciable magnetic field. The natural organization of these spins in materials constitutes regions of "magnetic domains," which are a part of the origin of the magnetism in an ordinary bar magnet.

The goal of this week's lab is to increase your familiarity and understanding of magnetic fields. To get a head start, consider the interactions between the poles of two magnets.

Q1[10'] For each situation listed below, state whether the two poles will attract or repel each other when brought close together.

north pole & north pole ______________________________

north pole & south pole ______________________________

south pole & south pole ______________________________

Next, consider a magnet suspended by a string so that it is allowed to rotate about the axis of the string as shown in Figure 2. If this system is allowed to come to rest, the magnet will line itself up with the horizontal component of the earth's magnetic field and the north end of the magnet will point in the direction of magnetic north.

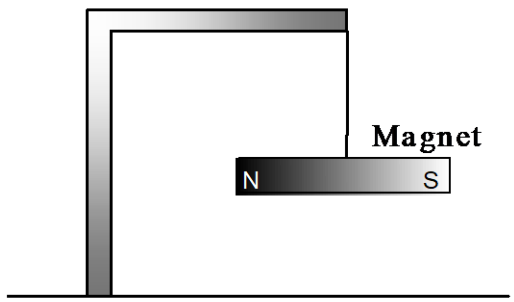

Figure 2. A magnet suspended by a string

Q2[10'] Suppose a stationary bar magnet is placed directly underneath the suspended magnet, as shown in Figure 2. Draw the final alignment of the suspended magnet on Figure 3.

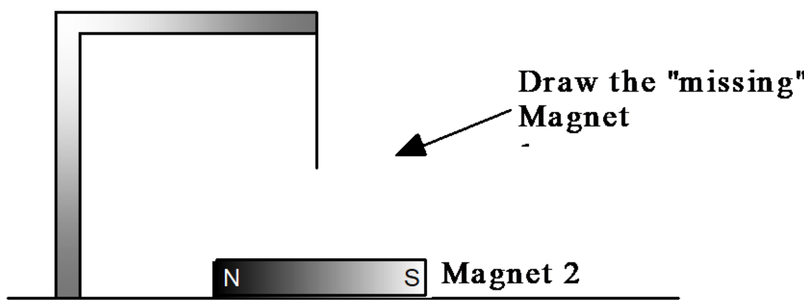

Figure 3. The situation of Question 2

You can also think of the problem in terms of field lines. The stationary magnet in Figure 3 generates magnetic field lines, pointing from its north pole to its south pole. The suspended bar magnet then aligns itself *along* those lines.

Q3[10'] Draw a few field lines in Figure 3, indicating the direction of the **B** field created by the stationary bar magnet. Once the suspended magnet has aligned itself with the magnetic field, which of its poles points in the *same direction* as the external field produced by Magnet 2?

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Consider a compass placed at point P in the situation of Figure 4. Similar to the magnet hanging from the string, a typical compass consists of a magnet which is suspended in such a way that it is free to rotate. The compass needle is nothing more than a tiny bar magnet, with its north pole indicated in some way (often with the letter 'N', or with a red color).

Figure 4. Draw the compass arrow through point P

Q4[10'] In Figure 4, a compass is placed at point P near a bar magnet. Draw an arrow in the direction that the *north* pole of the compass would point at point P. (Hint: You may want to first sketch in the field generated by the large magnet.)

Q5[10'] The north pole of a compass always points to near the *geographic* North Pole of the earth. What sort of *magnetic* pole therefore exists near the geographic North Pole of the Earth?

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When discussing the electric field we made use of the concept of a *positive test charge*. For a magnetic field we will use a similar idea, a *test compass*. By definition, the magnetic field at point P points in the same direction as the north pole of the compass.