Name ______________________ Date ______________

20Feb07 LeClair

# PH 102 Quiz 4: Magnets and Such

1. Consider a proton moving with a speed of $1 \cdot 10^5$ m/s through the earth's magnetic field ($|\vec{\mathbf{B}}| = 55\,\mu$T). When the proton moves east, the magnetic force acts straight upward. When the proton moves northward, no force acts on it. What is the direction of the magnetic field?

⊗ North
○ South
○ East
○ West

The proton will experience no force when it is moving in a direction parallel to the magnetic field. We already know then that the magnetic field is either pointing north or south, since the proton experiences no force when traveling north. But is it north or south?

When the proton moves east, it experiences a force upward. We can use the first right-hand rule to find definitively the direction of the $\vec{\mathbf{B}}$ field. Put the fingers of your right hand along the proton's velocity (east), and point the back of your hand in the direction of the resulting force (up). Your right thumb now points along the direction of $\vec{\mathbf{B}}$ - north.

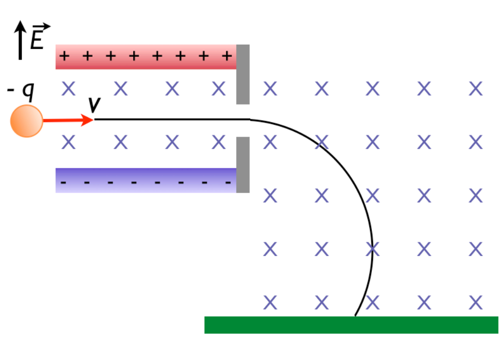
2. What is the magnitude of the magnetic force in the previous example?

○ $2.2 \cdot 10^{-9}$ N
○ $6.6 \cdot 10^{-15}$ N
⊗ $8.8 \cdot 10^{-19}$ N
○ $4.4 \cdot 10^{-13}$ N

The magnitude of the magnetic force has to be given by $F = qvB$:

$$F = qvB = (1.6\times10^{-19}\,\text{C})(1\times10^5\,\text{m/s})(55\,\mu\text{T}) = (1.6\times10^{-19}\,\text{C})(1\times10^5\,\text{m/s})(55\times10^{-6}\,\text{T}) = 8.8\times10^{-19}\,\text{N}$$

Strictly speaking, we have to note that $1\,\text{T} = 1\,\text{N/A}\cdot\text{m}$ to be sure the units come out right. So long as you use the proper SI units for everything - C, m/s, T - you can usually be sure everything will work out all right.




3. The figure shows a simplified mass spectrometer. Particles with charge $q$ and mass $m$ enter at left with a velocity $v$, and encounter a region with both an $E$ and $B$ field as shown. What is the relationship between $v$, $B$, and $E$ for particles that make it through the aperture in the middle of the detector?

○ $EB = v$
⊗ $E/B = v$
○ $E^2/B = v$
○ $B/E = v$

For the particle to make it through the aperture, it has to travel in a straight line. This will only happen if there is no net up-down force on the particle.

We can see that the $\vec{\mathbf{E}}$ field gives an upward force on the negative charge $-q$, while the $\vec{\mathbf{B}}$ field gives a downward force from the first right-hand rule. For there to be no net force, these two have to balance:

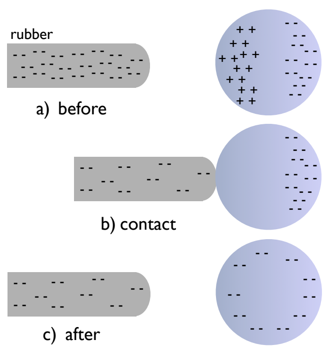
$$\begin{aligned} F_B &= F_E \\ -qvB &= -qE \\ \cancel{-q}vB &= \cancel{-q}E \\ v &= E/B \end{aligned}$$

4. Once the particle enters the second region of the detector from the previous question, it is in a region of magnetic field only. In this region, the particle travels in a circular path. What is the radius of the circle?

○ $r = mB/qv$
○ $qvB/m$
○ $r = qB/mv$
⊗ $r = mv/qB$

If the particle moves in a circular path, the net force it experiences must be equal to the centripetal force:

$$\begin{aligned} F_B &= F_C \\ qvB &= mv^2/r \\ rq\cancel{v}B &= mv^{\cancel{2}} \\ rqB &= mv \\ r &= mv/qB \end{aligned}$$




5. Permanent magnets sticking to a refrigerator door happens because the permanent magnet is able to induce magnetic poles in the steel of the door. This process is analogous to electrically charging objects by *induction*, where a charged object induces opposing charges in a conductor without contact.

Can a process like *conduction*, where a charged object transfers some of its charges to another, happen with magnets? Refer to the figure at left for the analogy.

⊗ No, because there are no single magnetic charges.
○ Yes, but it is a small effect since $\mu_0 << \epsilon_0$
○ Yes, this is how permanent magnets become magnetized
○ No, because magnetic poles are not mobile.

I suggest you read the section in Chapter 15 on charging by induction once more, and the answer should be clear.