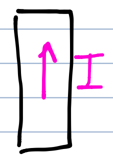
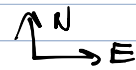
Example

A horizontal rod of mass m and length L is aligned in a N-S direction carrying a current I toward the N. When a uniform B field is applied to the entire length, the magnetic force on the rod keeps it suspended at rest. Find the minimum B necessary.



$\vec{F} = I\vec{L} \times \vec{B}$



Need at least a component of $\vec{B}$ pointing W.

(and completely toward W for the minimum B necessary)

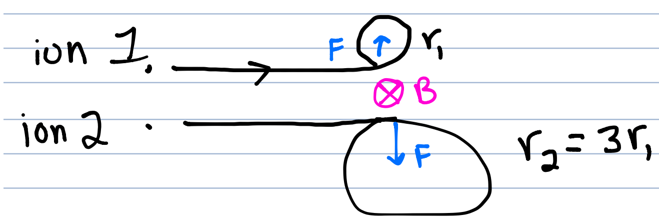
for balancing, $mg = ILB \rightarrow B = \frac{mg}{IL}$

#5: 2mm diameter copper, 1m long, current 1A

$B_{min} = \frac{\rho_{cu} \ell \pi r^2 g}{I \ell} = \frac{8.9\cdot 10^3 \, kg/m^3 \; \pi (10^{-3} m)^2 \; 9.8 \, m/s^2}{1A} = 0.27 T$ or 2700 Gauss

($B_{earth} \sim 0.5G$)

example Two ions w/ the same initial velocity enter a region with a uniform B field.



a) What are the charge signs?
#1 +
#2 −

b) if the ion masses are equal, what is the charge ratio?

$F = qvB = \frac{mv^2}{r}$

$\rightarrow q = \frac{mv}{rB} \Rightarrow \frac{q_2}{q_1} = \frac{r_1}{r_2} = \frac{1}{3}$

ch11/s3.html Concept Q

look from the side $I \otimes \uparrow B \rightarrow \vec{F} = I\vec{L} \times \vec{B}$

Question #1 (A)

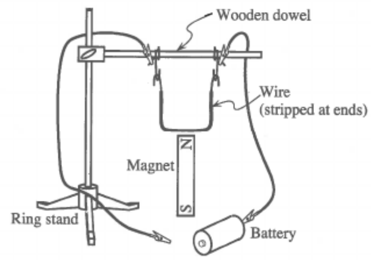
Question #2 (C)

ch11/s4.html (E) actually, also need m & v, too

I. The magnetic force on a current-carrying wire in a magnetic field

Obtain the following equipment:

- magnet
- wooden dowel
- ring stand and clamp
- battery
- two paper clips
- two alligator-clip leads
- 30 cm piece of connecting wire
- magnetic compass
- enlargement showing magnet and wire



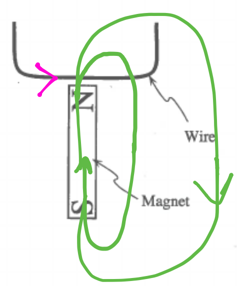
Hang the connecting wire from the paper clips as shown so that it swings freely. Do not connect the wires to the battery until told to do so.

A. On an enlargement of the figure below, sketch field lines representing the magnetic field of the bar magnet. Show the field both inside and outside the magnet.

On the diagram, indicate the direction of the current through the wire when the circuit is complete.

Predict the direction of the force exerted on the wire by the magnet when the circuit is complete. Explain.

out of the page



Check your prediction. (Do not leave the battery connected for more than a few seconds. The battery and wires will become hot if the circuit is complete for too long.)

B. Make predictions for the following five situations based on what you observed in part A. Check your answers only after you have made all five predictions.

1. The magnet is turned so that the south pole is near the wire while the battery is connected.

   Prediction:

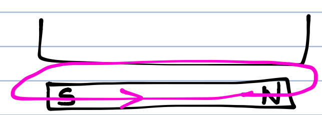
   Observation:

2. The leads to the battery are reversed (consider both orientations of the magnet).

   Prediction:

   Observation:

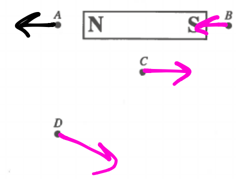
Question 5 on holding bar magnet parallel to wire



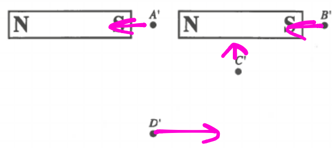
no force since $\sin 0^\circ = 0$

Pretest: Magnets and magnetic fields Name ______________

1. At each of the four labeled points (*A–D*), sketch a vector representing the magnetic field around the bar magnet.



2. A second bar magnet identical to the first one is placed to the left of point *A*. (See figure below.) At each of the four labeled points (*A'–D'*), sketch a vector representing the net magnetic field.

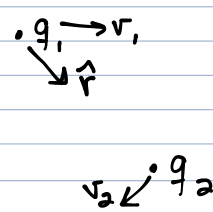


3. Rank the magnitude of the magnetic field at points *A*, *B*, *A'*, and *B'*. If the magnitude of the magnetic field at any point is zero, state that explicitly. Explain your reasoning. (If you do not have enough information to determine the ranking, explain what information you would need.)

$|B(A')| > |B(B')| > |B(A)| = |B(B)|$

Chapter 12

a moving charge creates a B field!



electric

$\vec{E}_1 = \frac{1}{4\pi\epsilon_0}\frac{q_1}{r^2}\hat{r}$

$\vec{F}_{1\,on\,2} = q_2\vec{E}_1$

$= \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$

magnetic

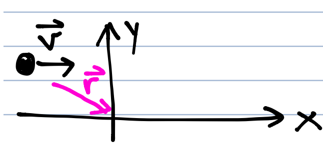
$\vec{B}_1 = \frac{\mu_0}{4\pi} q_1 \frac{\vec{V}_1 \times \hat{r}}{r^2}$

$\vec{F}_{1\,on\,2} = q_2 \vec{V}_2 \times \vec{B}_1$

$= q_2 \vec{V}_2 \times \left[\frac{\mu_0}{4\pi} q_1 \frac{\vec{V}_1 \times \hat{r}}{r^2}\right]$

example A proton is moving with $\vec{v} = 3.6 \cdot 10^7\,m/s\,\hat{\imath}$ along line $y = +0.30\,\mu m$

a) Find $\vec{B}(x=0, y=0)$ when proton is at $X = -0.40\,\mu m$



$\vec{r} = 0.40\,\mu m\,\hat{\imath} - 0.30\,\mu m\,\hat{\jmath}$

$r = \sqrt{(0.40\,\mu m)^2 + (-0.30\,\mu m)^2} = 0.5\,\mu m$

$\hat{r} = \frac{\vec{r}}{r} = 0.80\hat{\imath} - 0.60\hat{\jmath}$

$\vec{v} \times \hat{r} = v(\hat{v} \times \hat{r}) = v[\hat{\imath} \times (0.8\hat{\imath} - 0.6\hat{\jmath})] = v(-0.6\hat{k})$

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2} = \frac{4\pi \cdot 10^{-7} \frac{T \cdot m}{A}}{4\pi} \frac{(1.6 \cdot 10^{-19} C)(3.6 \cdot 10^{7} m/s)(0.6)(-\hat{k})}{(0.5\ um)^2} = 1.4 \cdot 10^{-6} T (-\hat{k})$$