APPC, E & M: Unit C HW 1

Name: ____________________________________
Hr: ___ Due at beg of hr on: ____________

UC, HW1, P1
Reference Video: "Force on a Charged Particle Moving in a Magnetic Field (Part I)"
YouTube, lasseviren1, INTERACTIONS OF B FIELDS WITH MOVING CHARGES playlist

A. What is the standard SI unit for measuring the strength of a magnetic field?

B. Write the vector cross-product equation that is used to determine the magnetic force on a charge that is moving with a particular velocity through a magnetic field of a particular strength.

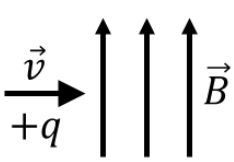
C. Next to the fingers and thumbs of the pics below, draw arrows and label which vector (i.e., $\vec{v}$, $\vec{B}$, or $\vec{F_B}$) points in which direction. Next to your $\vec{v}$ vector (and its label) on each diagram, write either $+q$ or $-q$ to show which charges that rule applies to. On the palms (which face OUT of the page, i.e., towards you), use either ⊗ or ⊙ to show the direction of the "palm" vector, and label that vector as well.

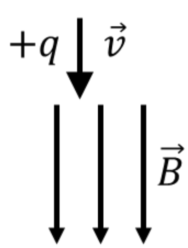
RIGHT-HAND RULE

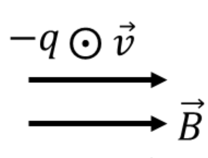
LEFT-HAND RULE

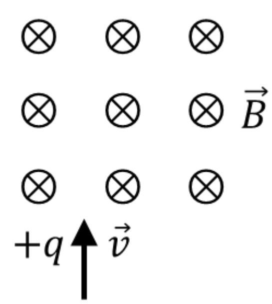
D. For each scenario at the bottom of the page, identify the direction of the magnetic force, in this way:

- (1) Use an arrow, or a ⊗, or a ⊙... to show the direction of the INITIAL magnetic force, if any.
- (2) Write $\vec{F_B}$ by the symbol you wrote in Part (1).
- (3) Use words to state the Part (1) direction: LEFT / RIGHT; TOWARD TOP OF PAGE / TOWARD BOT. OF PAGE; INTO PAGE / OUT OF PAGE
- (4) If there is no magnetic force, merely write "zero $\vec{F_B}$."





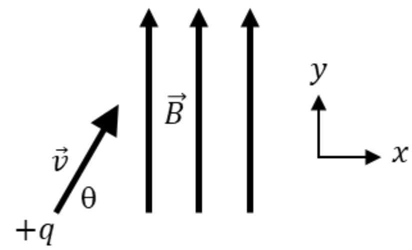




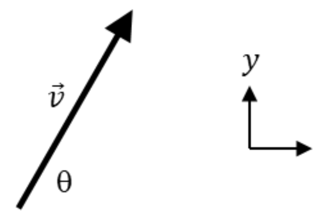
UC, HW1, P2

Reference Videos: (1) "Magnetic Force on a Charged Particle Moving in a Magnetic Field (Part II)"
(2) "Force on a Charged Particle Moving in a Magnetic Field (Part III)"
YouTube, lasseviren1, INTERACTIONS OF B FIELDS WITH MOVING CHARGES playlist

Here, we will investigate more about the forces and behaviors that result when moving charges interact with uniform magnetic fields. First, consider the figure at right, in which a uniform magnetic field of magnitude ***B*** points entirely in the *y*-direction. Entering this field is a charge of magnitude *q* moving with a velocity ***v***, which is directed at an angle θ, relative to the *x*-direction. It is very important to note that the velocity is partially in the *x*- and partially in the *y*-direction. Here we go…



A. At right is an enlarged figure of the velocity vector. Into this figure, draw two new vectors, namely the *x*- and *y*-components of the charge's velocity. Label these new vectors v_x and v_y.



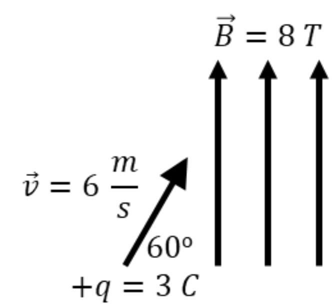
B. Which of the components of velocity will be *unaffected* (*unchanged*) by the ***B*** field? (CIRCLE) v_x v_y

C. Which of these components of velocity WILL be affected by the ***B*** field? (CIRCLE) v_x v_y

D. Write again the cross-product equation that relates magnetic field, charge, velocity, and force. (If you need a hint, refer back to Problem 1, Part B.)

E. Your answer to Part D suggests there WILL be a force on the charge as a result of… v_x v_y

Now consider the diagram at right to answer the following questions.

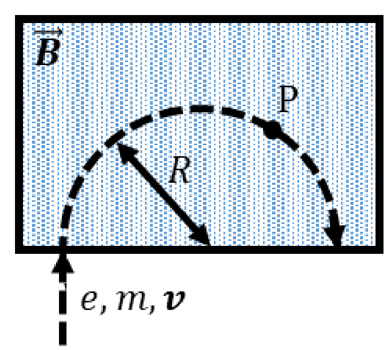


F. Determine the magnitude of the magnetic force on the charge.

G. Determine the initial direction of the magnetic force, i.e., the direction the force has at the first instant the charge enters the ***B*** field. Either state this direction in words OR represent the direction with a symbol.

H. How far in the *y*-direction will the charge have traveled, five seconds after it enters the ***B*** field?

Consider the final diagram at right, which shows the path of an electron of charge *e*, mass *m*, and velocity ***v***, (1) before it enters a region of uniform magnetic field of magnitude ***B***, as well as (2) for a short time after it enters the uniform field, as it curves around in a path of radius *R*.



I. Into the figure, use symbols to represent the direction of the ***B*** field.

J. Into the figure, draw a vector starting at Point P that shows the direction of the net force on the electron at Point P.

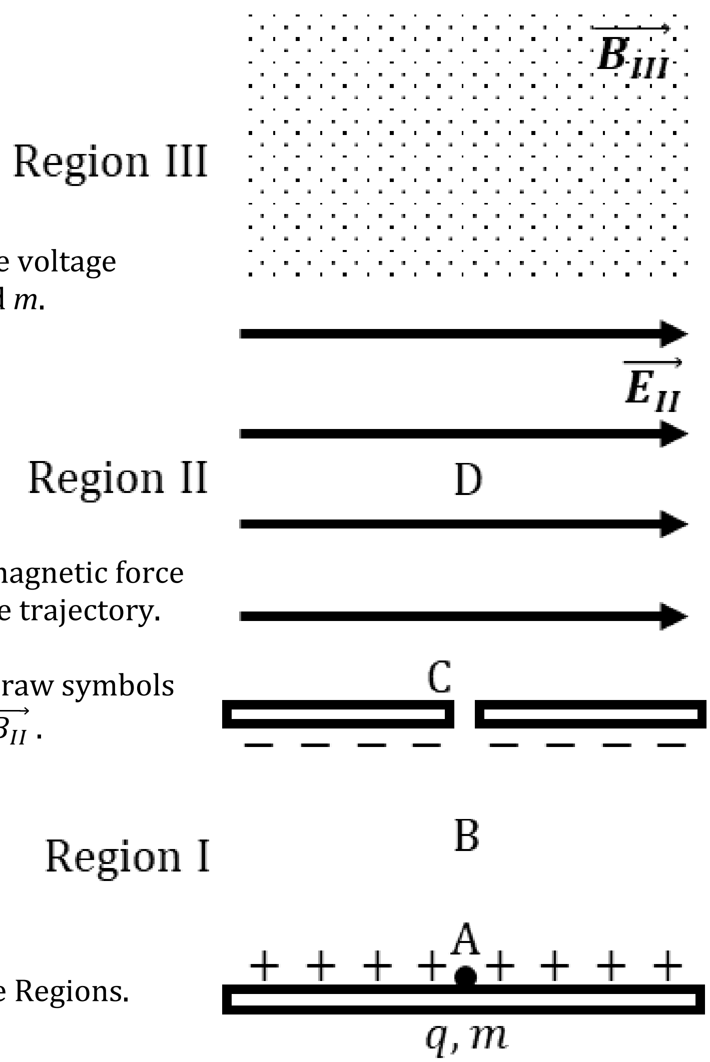
K. In terms of *e*, *m*, ***v***, and *R*, write an expression for the magnitude of the uniform magnetic field, i.e., *B* = ?

UC, HW1, P3
Reference Video: "Charged Particles Moving Through Electric and Magnetic Fields"
YouTube, lasseviren1, INTERACTIONS OF B FIELDS WITH MOVING CHARGES playlist

A. For a particle of charge q and mass m moving at a velocity $\boldsymbol{v}$ through constant gravitational, electric, and magnetic fields $\boldsymbol{g}$, $\boldsymbol{E}$, and $\boldsymbol{B}$, respectively, write the equation that could be used to determine the net force $\boldsymbol{F}$ on the particle, due to these three fields.

B. In your Part A answer…Why is it that, in the real world, the gravitational contribution to the net force on the particle is often ignored?

The diagram shows a (+) charge q of mass m that begins from rest at Pt. A, on a (+) plate. The particle accelerates through Region I, traveling in a straight line toward a (−) plate with a hole at Pt. C. The particle achieves a speed v by the time it reaches C. After passing through the hole, it continues in a straight line through Region II, where a uniform E field $\boldsymbol{E_{II}}$ acts, pointing right, as shown. When it reaches Region III, the particle bends in a circular trajectory due to a B field $\boldsymbol{B_{III}}$ directed out of the page, as shown by the small dots. Refer to the figure and the description above, and answer the following questions.



C. In Region I, draw vectors that represent the electric field between the two plates. Label this field $\overrightarrow{E_I}$.

D. At Point B, draw and label a vector $\overrightarrow{F_{EI}}$ to show the direction of the electric force on q at Pt. B.

E. Use energy conservation to write an equation for the voltage difference V between the plates, in terms of v, q, and m.

F. At Point D, draw and label a vector $\overrightarrow{F_{EII}}$ to show the direction of the electric force on q at Pt. D.

G. At D, draw a vector $\overrightarrow{F_{BII}}$ to show the direction the magnetic force acts within Region II for q to maintain a straight-line trajectory.

H. Consistent with your Part G answer… In Region II, draw symbols to represent the $\boldsymbol{B}$ field there. Label these symbols $\overrightarrow{B_{II}}$.

I. Assuming q emerges at Point C having a speed v and continues moving at this speed as it passes through Region II, write an expression for the magnitude of B_{II}.

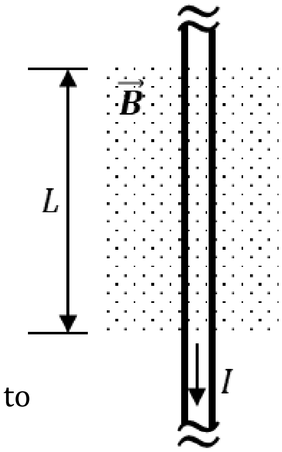
J. Draw the trajectory of q as it passes through all three Regions.

K. In terms of the given variables, write an expression for the particle's radius of curvature R, once it reaches Region III.

L. In general, why can NO work EVER be done on a particle by a magnetic force?

UC, HW1, P4

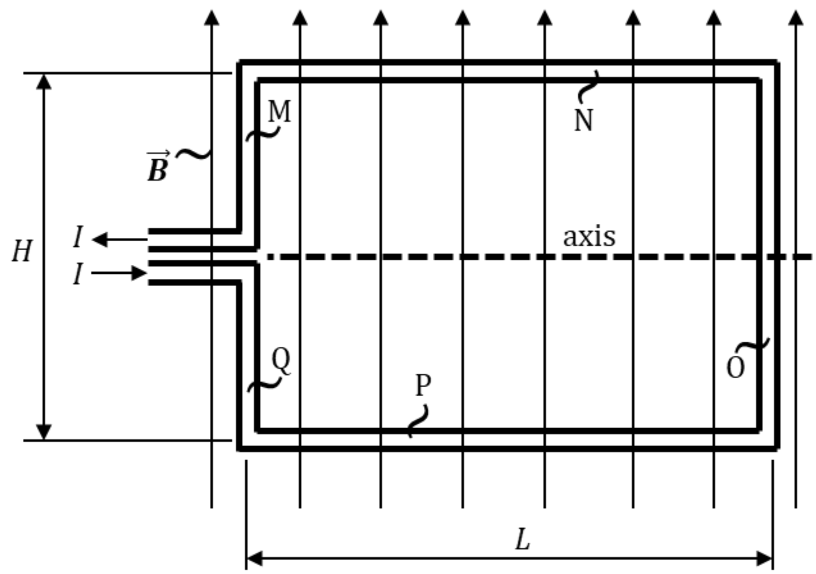
Reference Video: "Forces on a Current-Carrying Wire"
YouTube, lasseviren1, INTERACTIONS OF B FIELDS WITH MOVING CHARGES playlist



A. Write the vector equation for the magnetic force $\boldsymbol{F_B}$ on a wire of length L that lies within a magnetic field $\boldsymbol{B}$ and carries a conventional current I.

B. In the figure above, draw and label a vector $\overrightarrow{F_B}$ (with the tail centered on the wire) to show the direction the magnetic force acts on the length of wire within the $\boldsymbol{B}$ field.

The figure at right shows a rectangular loop of metal wire having side lengths L and H. The loop is able to rotate about the axis shown and carries a current I, also shown. The loop's side lengths are labeled M, N, O, P, and Q. At the instant shown, the magnetic field $\boldsymbol{B}$ is parallel to sides M, O, and Q.



C. Draw and label current I arrows on sides M, N, O, P, and Q.

D. Of sides M, N, O, P, and Q…On which ones will there be zero magnetic force?

E. Briefly explain your Part D answer.

F. Into the figure, next to each of the sides you DIDN'T mention in your Part D answer, write $\overrightarrow{F_{BX}}$, where X is the letter of each side you are labeling. Also, draw symbols into the figure to indicate the direction of each of these nonzero $\overrightarrow{F_{BX}}$ vectors.

G. For EACH $\overrightarrow{F_{BX}}$ vector you included in your Part F answer, write an equation, in terms of the given variables, that gives the magnitude of that $\overrightarrow{F_{BX}}$ vector. (HINT: You will write more than one equation.)

H. What is true about the magnitude of each of your Part G answers?

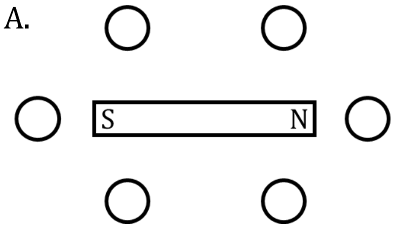
I. Use your Part G answers and the figure to write a single equation for the total amount of torque τ that is being exerted on the loop at the instant shown in the figure.

UC, HW1, P5

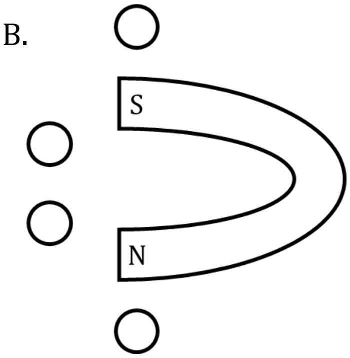
Reference Video: “Review of Unit on Magnetic Forces on Moving Charges (Part I)”
YouTube, lasseviren1, INTERACTIONS OF B FIELDS WITH MOVING CHARGES playlist

On the two figures at right, draw needles on the compasses (i.e., the circles) to show the direction of the magnetic field at each location around the two magnets shown. (HINT: Recall that a compass IS a tiny magnet which will point in the same direction that a *B* field points.)

A.



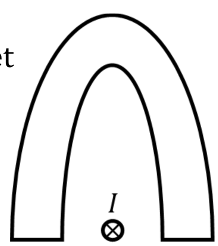
B.



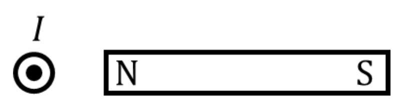
C. Now, on the figure for Part B above, draw a circle (about THIS big…**O**) on the imaginary line that would connect the letter N with the letter S, and equidistant from each letter. This **O** represents a current-carrying wire that runs into-and-out-of the page, between the poles of the horseshoe magnet shown.

D. We want the **O**-wire above to experience a magnetic force that pushes the wire to our left. Draw into the figure (and label) this vector $\overrightarrow{F_B}$, with the tail centered on the **O**. Also, WITHIN the **O**, draw a symbol to show the direction conventional current must travel in order to achieve the to-the-left $\overrightarrow{F_B}$.

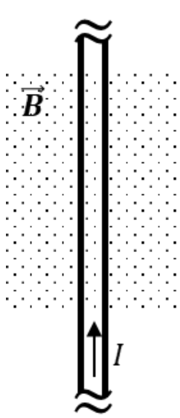
E. In this figure, label the N and S poles of the magnet such that the magnetic force on the wire would be toward the top of the page.



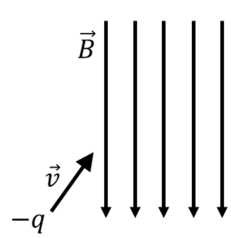
F. In which direction will this wire be pushed?



G. In which direction will this wire be pushed?



H. Here, an electron is about to enter a region having a uniform magnetic field. In which direction will the magnetic force act, at the first moment the electron enters the ***B*** field?



I. Describe in some detail the trajectory of the electron shown in Part H, once it enters the field and then after it continues to move through the field.