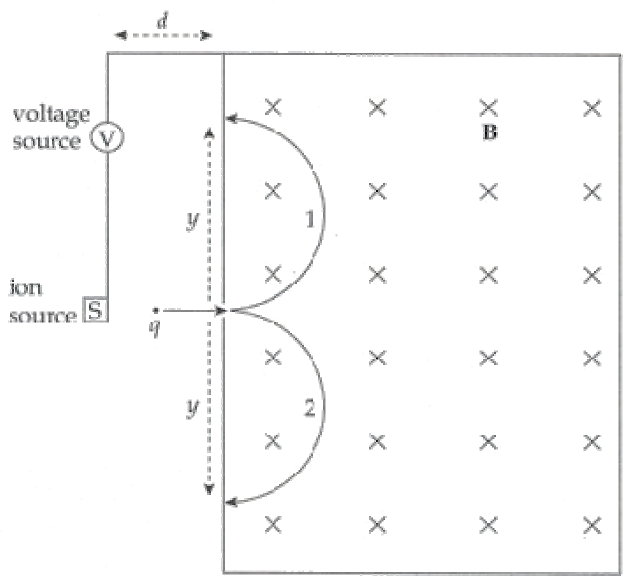
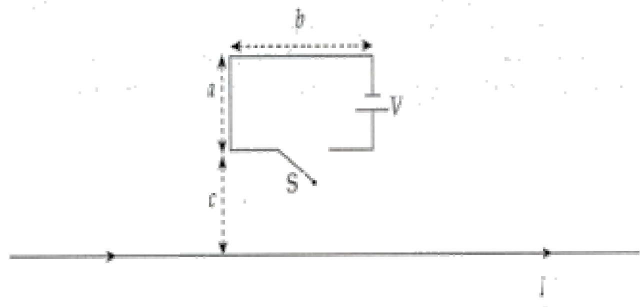
AP Physics C Magnetic Field & Force Review   Name:

1.   The diagram below shows a simple mass spectrograph. It consists of a source of ions (charged atoms) that are accelerated (essentially from rest) by the voltage V and enter a region containing a uniform magnetic field, **B**. The polarity of V may be reversed so that both positively-charged ions (cations) and negatively-charged ions (anions) can be accelerated. Once the ions enter the magnetic field, they follow a semicircular path and strike the front wall of the spectrograph, on which photographic plates are constructed to record the impact.



a) What is the acceleration of an ion of charge q just before it enters the magnetic field?
b) Find the speed with which an ion of charge q enters the magnetic field.
c) (i) Which semicircular path, 1 or 2, would a cation follow?
   (ii) Which semicircular path, 1 or 2, would an anion follow?
d) Determine the mass of a cation entering the apparatus in terms of y, q, B, and V.
e) Once a cation of charge q enters the magnetic field, how long does it take to strike the photographic plate?
f) What is the work done by the magnetic force in the spectrograph on a cation of charge q?

2. A wire of diameter *d* and resistivity *ρ* is bent into a rectangular loop (of side lengths *a* and *b* and fitted with a small battery that provides a voltage *V*. The loop is placed at a distance c from a very long, straight wire that carries a current *I* in the direction indicated in the diagram.



(Express all answers in terms of *a, b, c, d, ρ, V, I*, and fundamental constants.)

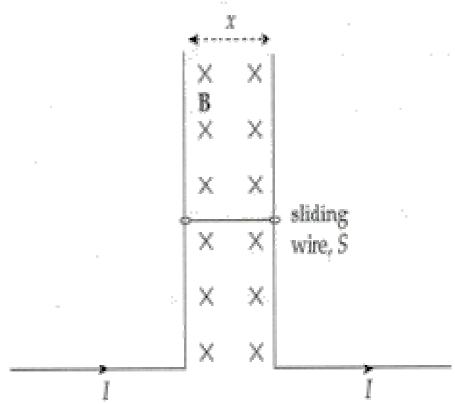
a) When the switch S is closed, find the current in the rectangular loop.

b) What is the magnetic force (magnitude and direction) exerted on the loop by the long straight wire?

(c) The wire of the rectangular loop is then reshaped into a circle. What will be the radius of the circular loop?

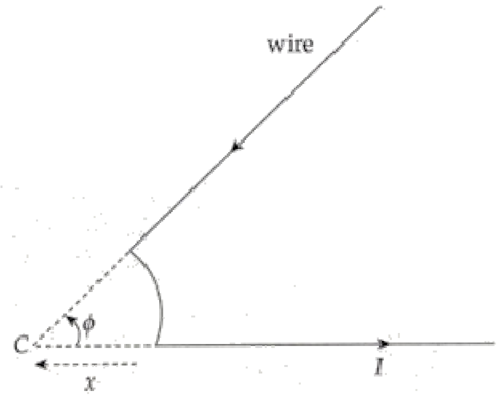
(d) If the loop constructed in part (c) were then threaded around the long, straight wire (that the straight wire passed through the center of the circular loop), what would be magnetic force on the loop now?

(e) In the following diagram, two fixed L-shaped wires, separated by a distance x, are connected by a wire that's free to slide vertically.



The mass of the sliding wire, *S*, is *m*. If the sliding wire *S* crosses a region that contains a uniform magnetic field **B**, how much current must be carried by the wire to keep *S* from sliding down (due to its weight)?

3. The figure below shows two long, straight wires connected by a circular arc of radius x that subtends a central angle φ. The current in the wire is I.



a) Find the magnetic field (magnitude and direction) created at point C. Write your answer in terms of x, φ, I, and fundamental constants.

b) A particle of charge $+q$ is placed at point C and released. Find the magnetic force on the particle.

c) A second long, straight wire is set up perpendicular to the plane of the page through C, carrying the same current, I as the wire pictured in the diagram but directed out of the page. Determine the magnetic force per unit length between the wires.

4. For a conducting rod that carries a current I, the current density is defined as the current per unit area: $J = I/A$.

Part 1. A homogeneous cylindrical rod of radius R carries a current whose current density, J, is uniform (constant); that is, J does not vary with the radial distance, r, from the center of the rod.

(a) Determine the current, I, in the rod.

(b) Calculate the magnitude of the magnetic field for

(i) $r < R$

(ii) $r > R$, writing your answers in terms of r, R, and I.

Part 2. A non-homogeneous cylindrical rod of radius R carries a current whose current density, J, varies with the radial distance, r, from the center of the rod according to the equation $J = \sigma r$, where σ is a constant.

(c) What are the units of σ ?

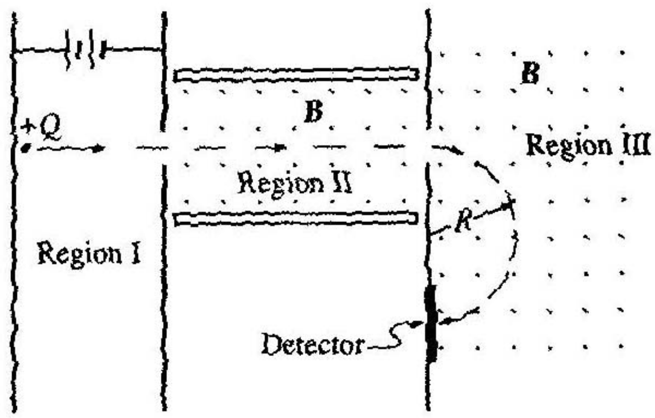
(d) Determine the current, I, in the rod.

(e) Calculate the magnitude of the magnetic field for

(i) $r < R$

(ii) $r > R$, writing your answers in terms of r, R, and J.

5.



In the mass spectrometer shown above, particles having a net charge $+Q$ are accelerated from rest through a potential difference in Region I. They then move in a straight line through Region II, which contains a magnetic field **B** and an electric field **E**. Finally, the particles enter Region III, which contains only a magnetic field **B**, and move in a semicircular path of radius R before striking the detector. The magnetic fields in Regions II and III are uniform, have the same magnitude B, and are directed out of the page as shown.

(a) In the figure above, indicate the direction of the electric field necessary for the particles to move in a straight line through Region II.

In terms of any or all the quantities Q, B, E, and R, determine expressions for

(b) the speed v of the charged particles as they enter Region III;

(c) the mass m of the charged particles;

(d) the accelerating potential V in Region I;

(e) the acceleration a of the particles in Region III;

(f) the time t required for the particles to move along the semicircular path in Region III.