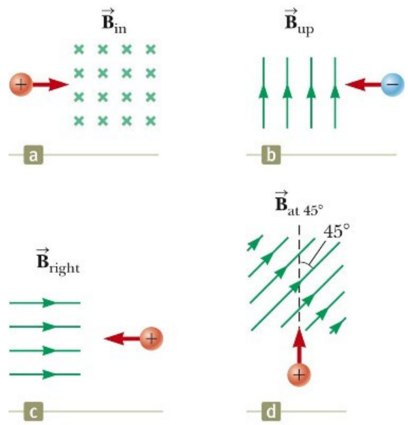
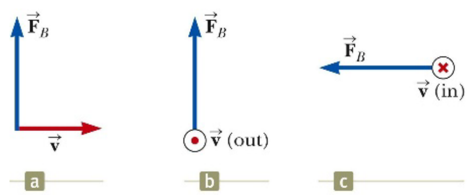
University Physics II

Homework Set 7

1. Determine the initial direction of the deflection of the charged particles as they enter the magnetic fields shown in the figure below.



2. Find the direction of the magnetic field acting on a positively charged particle moving in the various situations as shown in the figure below if the direction of the magnetic force acting on it is as indicated.



3. A proton moves with a velocity of $\vec{\mathbf{v}} = (2\,\hat{\mathbf{x}} - 4\,\hat{\mathbf{y}} + \hat{\mathbf{z}})$ *m/s* in a region in which the magnetic field is $\vec{\mathbf{B}} = (\hat{\mathbf{x}} + 2\,\hat{\mathbf{y}} - \hat{\mathbf{z}})$ T. What is the magnitude of the magnetic force this particle experiences?

4. A proton travels with a speed of 5.02×10^6 *m/s* in a direction that makes an angle of 60.0º with the direction of a magnetic field of magnitude 0.180 T in the positive *x* direction. What are the magnitudes of:
   a. The magnetic force acting on the proton
   b. The proton's acceleration

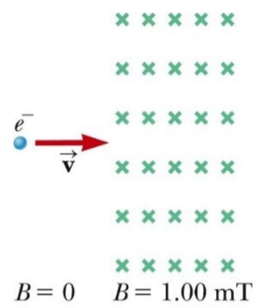
5. An electron moves in a circular path perpendicular to a uniform magnetic field with a magnitude of 2.00 *m*T. If the speed of the electron is 1.50×10^7 *m/s*, determine:
   a. The radius of the circular path
   b. The period of the orbit – the time interval required to complete one revolution

6. ** A particle with charge *q* and kinetic energy *K* travels in a uniform magnetic field of magnitude *B*. If the particle moves in a circular orbit of radius *R*, find expressions for:
   a. The particles speed in terms of *K*, *R*, *q* and *B*
   b. The particles mass in terms of *K*, *R*, *q* and *B*

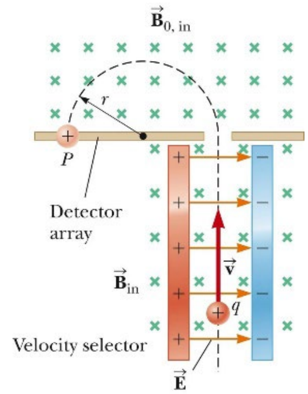
7. A cosmic ray proton in interstellar space has an energy of 10.0 MeV and executes a circular orbit having a radius equal to that of Mercury's orbit around the Sun (5.80×10^{10} *m*). What is the magnetic field in that region of space?

   Hint: Use your expression from problem 6, part (*b*) and solve for B

8. Assume the region to the right of a certain boundary contains a uniform magnetic field of magnitude 1.00 mT and the field is zero in the region to the left of the boundary as shown in the figure at right. An electron, originally traveling perpendicular to the boundary, passes through into the region containing the magnetic field.
    a. Determine the time interval required for the electron to leave the magnetic field region, noting that the electron's path is a semicircle.
    b. Assuming the maximum depth of penetration into the field is 2.00 cm, find the kinetic energy of the electron (in eV).



9. Consider the mass spectrometer shown schematically at right. The magnitude of the electric field between the plates of the velocity selector is 2.50×10^3 V/m, and the magnetic field in both the velocity selector and the deflection chamber has a magnitude of 0.035 T. Calculate the radius of the path for a singly charged ion having a mass $m = 2.18 \times 10^{-26}$ kg.

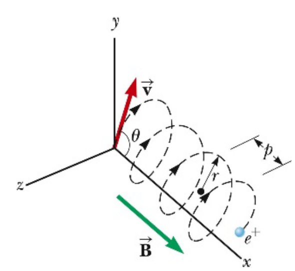


10. A velocity selector consists of electric and magnetic fields described by the expressions $\vec{\mathbf{E}} = E\,\hat{\mathbf{z}}$ and $\vec{\mathbf{B}} = B\,\hat{\mathbf{y}}$, with $B = 15.0$ mT. Find the value of E such that a 750 eV electron moving in the negative x direction is undeflected.

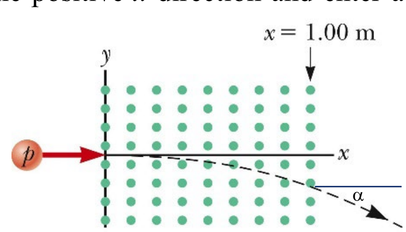
11. The amount of meat in prehistoric diets can be determined by measuring the ratio of the isotopes ^{15}N to ^{14}N in bones from human remains. Carnivores have a higher concentration of ^{15}N, so this ratio tells archaeologists how much meat was consumed. For a mass spectrometer that has a path radius of 12.5 cm for ^{12}C ions (*mass* 1.99×10^{-26} kg), find the separation distance (*in cm*) between the ^{14}N (*mass* 2.32×10^{-26} kg) and ^{15}N (*mass* 2.49×10^{-26} kg) isotopes at the detector.

    Hint: The ratio R/m is constant in both cases. Use that fact to find R for each isotope. Then find the separation distance using $d = 2(R_2 - R_1)$, which is the difference in diameters of the circular arcs they make.

12. A uniform magnetic field of magnitude 0.150 T is directed along the positive x axis. A **positron** (*an electron with a positive charge*) moving at a speed of 5.00×10^6 m/s enters the field along a direction that makes an angle of $\theta = 85.0^\circ$ with the x axis as shown in the figure at right. The motion of the particle is a helix. Calculate:
    a. The *pitch* (p)
    b. The radius r of the trajectory as seen from an end view



13. Protons having a kinetic energy of 5.00 MeV are moving in the positive x direction and enter a magnetic field $\vec{\mathbf{B}} = 0.0500\,\hat{\mathbf{z}}$ T directed out of the plane of the page and extending from $x = 0$ to $x = 1.00$ m as shown in the figure at right. Ignoring relativistic effects, find the angle α between the initial velocity vector of the proton beam and the velocity vector after the beam emerges from the field.



14. You are a technician testing the operation of a cyclotron. An **alpha particle** (*a helium nucleus with no electrons*) in the device moves in a circular path in a magnetic field $\vec{\mathbf{B}}$ that is directed perpendicular to the path of the alpha particle. You measure the number of revolutions per second (*the frequency f*) of the alpha particle as a function of the magnetic field strength B. The figure below shows your results and the best straight-line fit to your data.

    a. Use the graph to calculate the charge-to-mass ratio of the alpha particle.

    b. On the basis of your data, what is the mass of the alpha particle, which has a charge $+2e$? What is the percent error when compared to the actual value of 6.64×10^{-27} kg?

    c. With $B = 0.300$ T, what speed does an alpha particle have if the radius of its path is 12.0 *cm*?