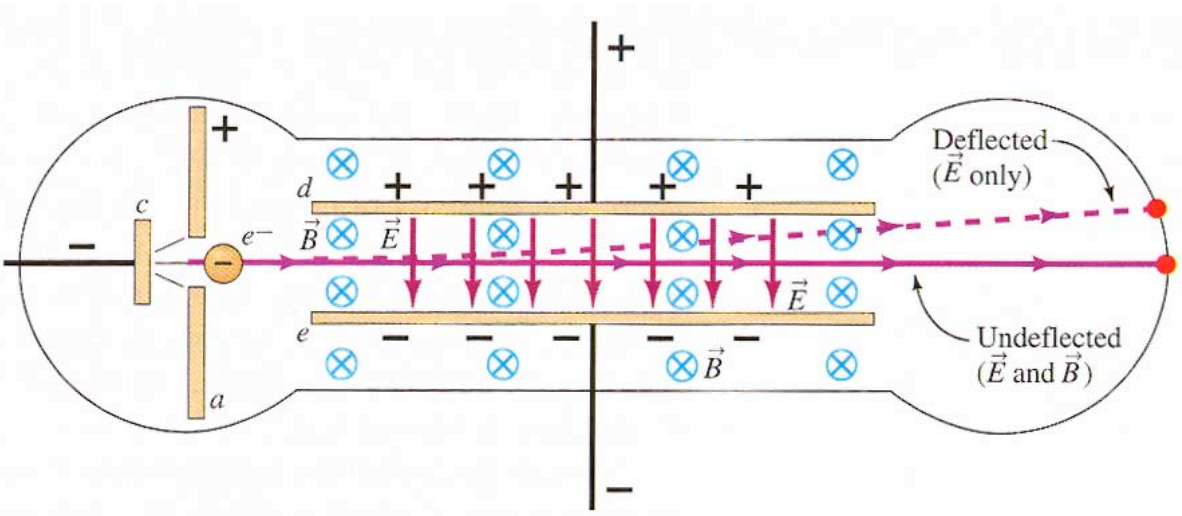
Problem Session
Magnetic Fields

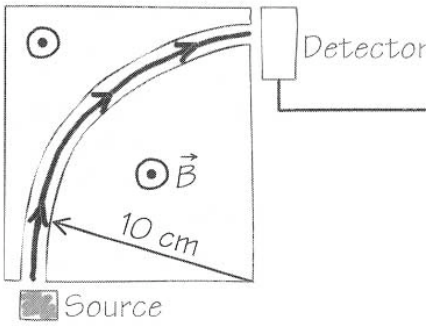
1. Singly charged uranium ions, ^{238}U, containing 92 protons, are accelerated from rest through a potential difference of 2 kV and enter a uniform magnetic field of 1.2 T directed perpendicular to their velocities. Determine the radius of the circular path followed by these ions.

2. ***The Charge-to-Mass ratio of the electron[1].*** In 1897 Sir Joseph John Thomson, the discoverer of the electron, performed a wide-ranging experiments whose results were crucial in the development of our understanding of the electrical nature of matter. A velocity selector was an important component to measure the charge-to-mass ratio of the electron. He first accelerated electrons from rest by passing them through an accelerating potential ΔV. The electrons accelerated in this way continued into a region of crossed electric and magnetic fields. Thomson adjusted the magnitudes of these fields until the electrons passed through the apparatus undeflected. ***Find the charge-to-mass ratio of the electrons, in terms of the accelerating potential ΔV, the electric field E and the magnetic field B in the velocity selector.***



[1] Fishbane, Gasiorowicz, Thornton. Physics for scientists and Engineers. 3rd edition. Prentice Hall, 2005.

3. The apparatus shown below is designed to measure the energy of alpha particles emitted by a radioactive source. (Alpha particles have a mass roughly four times the proton mass and a charge that is twice the proton charge.) The source is placed at the entrance of a channel that forms a quarter of a circle. A uniform magnetic field is applied perpendicular to the plane of the channel. Alpha particles with a specific velocity will make their way through the channel and be detected at the exit. All others will strike the walls and be lost. What is the range of values of B necessary to analyze alpha particles whose energy range up to 6 MeV?



4. ***The Mass Spectrometer:*** A particle with a charge of -2e is accelerated from rest through a potential difference of 4.2×10^4 V. Immediately at the end of the acceleration, the particle enters a magnetic field $\vec{B}$ = 2.4 T directed perpendicular to its motion. Once in the field, the particle undergoes a circular path with a diameter of 12 cm. Determine
   a) the mass of the particle,
   b) the period of its motion.

Answers

1. 8.3 cm

5. $\frac{q}{m} = \frac{E^2}{2VB^2}$

6. up to 3.54 T

7. a) 7.9×10^{-26} kg, b) $T = 6.5 \times 10^{-7}$ s.