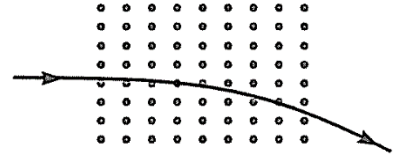


Week 9 Challenge Homework Solutions

Question 1

In an experiment we wish to find how many hydrogen atoms in a gas have their electrons ionized (removed). They are accelerated through a 4.50 MV potential and fired in the positive x-direction towards a magnetic field of magnitude $B = 0.045 \text{ T}$. The field points out of the plane, in the positive z direction. The field exists from $x = 0$ to $x = 1.00 \text{ m}$.



- Calculate the y component of an ionized hydrogen atom's momentum as they leave the magnetic field.
- Find the angle α between the initial velocity vector of the ionized hydrogen's atoms beam and the final velocity vector after the beam emerges from the field. Ignore relativistic effects.
- Why would the trajectory differ for a non-ionized hydrogen atom? What would be that trajectory?

(a) circular motion $\Rightarrow |F| = qvB = \frac{mv^2}{r}$

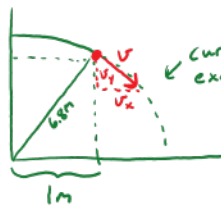
$\Rightarrow r = \frac{mv}{qB} \Rightarrow m, q, B \text{ are known}$

$v \Rightarrow \Delta U^E = \Delta KE$

$r = \frac{m}{qB} \left(\frac{2q\Delta V}{m} \right)^{1/2} \Rightarrow q\Delta V = \frac{1}{2}mv_f^2$

$r = \frac{1}{B} \left(\frac{2m\Delta V}{2} \right)^{1/2} \Rightarrow v_f = \sqrt{\frac{2q\Delta V}{m}}$

$r = 6.8 \text{ m} \leftarrow \text{this is } > 1 \text{ m} \Rightarrow \text{leaves B field } \checkmark$



$\Rightarrow \frac{v_y}{v_f} = \frac{1 \text{ m}}{6.8 \text{ m}} \Rightarrow v_y = \frac{v_f}{6.8} = \frac{v_f \Delta x}{r} = \frac{v_f \Delta x}{\left(\frac{mv_f}{qB} \right)}$

$v_y = \frac{qB}{m} \Delta x$

(b) $\Rightarrow p_y = mv_y = qB \Delta x = 7.2 \times 10^{-21} \text{ kg m/s}$

$\sin \theta = \frac{v_{fy}}{v_f} = \frac{1}{6.8}$

$\theta = 8.46^\circ$

(c) $\vec{F} = q\vec{v} \times \vec{B}$ Unionized \Rightarrow proton + electron \Rightarrow neutral q
 \Rightarrow no B force \Rightarrow no deflection $\Rightarrow \theta = 0!!$