Mississippi State University
Department of Physics and Astronomy
PH 2223 Lab

Magnetic Deflection of Electrons

How do charges in magnetic fields move? Magnetic field is an accelerating field but does not change the energy of a moving particle, how is that so?

You might often think where is magnetic field used anyway? Particle accelerators, high speed magnetic levitation trains, your drawing fan, everything from iPhone to its charger. But let us see go over the algorithm of working with magnetic fields in particle accelerators called cyclotrons which is based straight off Physics 101 ideas. Familiarize yourself with *Section 27.4* (P.925 - 927; Sears and Zemansky's University Physics, Ed.12). Note that there is a magnetic field **B**, an electric field **E** in between the 'D' looking semicircles, the gap in between the semicircular Ds is **d** and we are accelerating a positive charge (**q**)

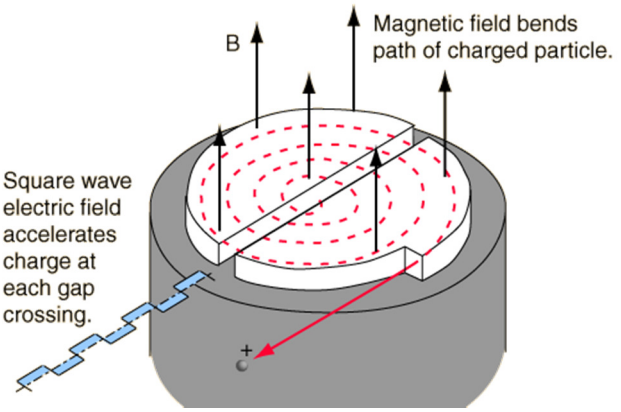

Fig.1: Schematic diagram of a Cyclotron

A. Working with **B** field.
   1. Indicate the magnetic force acting on a charged particle in terms of values and direction for the red positive charge coming out of accelerator.
   2. Note that if a particle is travelling clockwise (when looking down at semicircle Ds), the magnetic force is always acting towards the center of the circle. Therefore the force you got in part 1. can be equated with centripetal force learnt in physics I.
   3. Rearrange your terms and get an expression for linear velocity/angular velocity.
   4. So in 1 second how many full circles do the particles complete?

B. Working with **E** field.
   1. Remember every time the particle makes one full circle; it crosses the junction in between the semicircular Ds twice. The **E** field is present only at the junctions of the Ds. Every time a charged particle crosses the interface between the Ds, the particle's energy increases by $Vq = Edq$. So what is the energy that a charged particle gets in 1s? What is the velocity of an e^-, if **B** = 1T, **E** = $1NC^{-1}$, **d** = 1cm after 1s? ($V_{ini} \sim 0$)

Challenge

If a charge is travelling with velocity **v** in a straight line and I apply magnetic field perpendicular to **v**, how will the particle move? Now what if add an electric field $E = B.v$ perpendicular to both velocity and magnetic field? How now will the particle move?