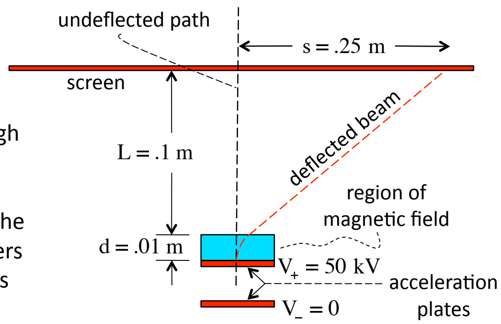
Problem 29.29

NOTE: This is a VERY obscure problem.

A beam electrons accelerate through 50 kV. It's deflected while moving through a B-fld that acts over .01 meters. The deflection motivates the beam to hit a screen that is .1 meters away a distance equal to .25 meters from the center-line (i.e., the undeflected path). How large must the B-fld be to do that?

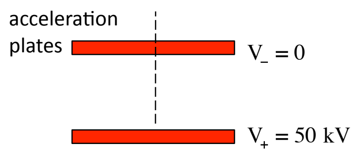


We know that: $qvB\sin 90^\circ = m\dfrac{v^2}{r}$

$$\Rightarrow\ B = \frac{mv}{qr}$$

To use this, we need to use the cons. of energy to get "v" and some exotic geometry to determine the radius "r" of the beam's magnetic-field-deflected path.

Using the conservation of energy through the accelerated portion of the flight:



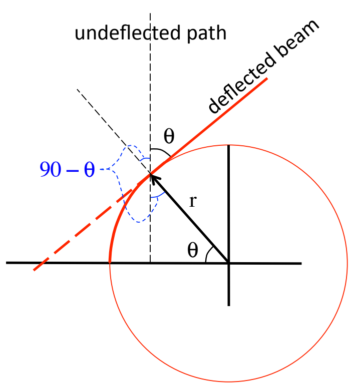
$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$0 \quad + \quad \cancel{qV_-}^{\,0} + \quad 0 \quad = \left(\frac{1}{2}\right)mv^2 + (-q)V_+$$

$$\Rightarrow\quad v = \left(\frac{2qV_+}{m}\right)^{1/2}$$

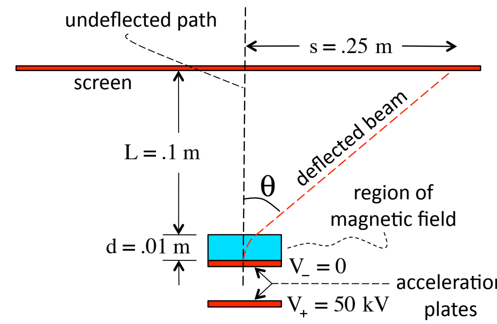
Determining the radius through which the charge was accelerated out of straight-line motion by the magnetic field is a little trickier.

Examine the sketch. Apparently, the angle between the undeflected line and the actual path is θ.



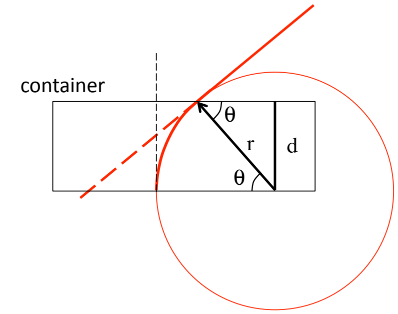
How so? From the .1 meter by .25 meter triangle (see sketch), we can write:

$$\theta = \tan^{-1}\left(\frac{.25}{.1}\right) = 68.2^\circ$$



Going back to our more refined sketch (inserting the container in which the magnetic field is provided), we can see that:

$$r = (d)\sin\theta$$
$$= (.01)\sin(68.2^\circ)$$
$$= .0108 \text{ m}$$



So going back to our magnetic field function, we can write:

$$B = \frac{mv}{qr}$$

$$\Rightarrow\ B = \frac{m\left(\frac{2qV_+}{m}\right)^{1/2}}{qr}$$

$$\Rightarrow\ B = \frac{\left(\frac{2mV_+}{q}\right)^{1/2}}{r}$$

$$\Rightarrow\ B = \frac{\left[\frac{2(9.1\text{x}10^{-31}\text{ kg})(50\text{x}10^3\text{ V})}{(1.6\text{x}10^{-19}\text{ C})}\right]^{1/2}}{(.0108\text{ m})}$$

$$= .07\text{ T}$$