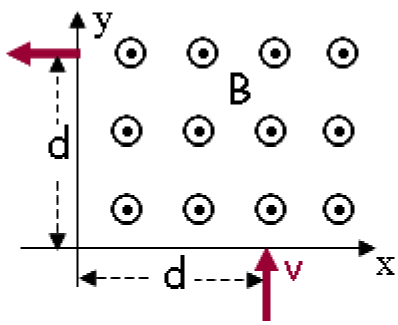
A charged particle of mass m = $5.4X10^{-8}$ kg, moving with constant velocity in the y-direction enters a region containing a constant magnetic field B = 2.6T aligned with the positive z-axis as shown. The particle enters the region at (x,y) = (0.56 m, 0) and leaves the region at (x,y) = 0, 0.56 m a time t = 782 μs after it entered the region.



1) With what speed v did the particle enter the region containing the magnetic field?

$$v = \frac{s}{t} = \frac{d\frac{\pi}{2}}{t}$$

V=(.56 m)/782 us (π/2)= .0011 x 10^{6}=1124.68 m/s

2) What is F_x, the x-component of the force on the particle at a time t_1 = 260.7 μs after it entered the region containing the magnetic field.

$$s_1 = d\theta_1 = vt_1 \Rightarrow \theta_1 = \frac{vt_1}{d}, \quad F = m\frac{v^2}{d} \Rightarrow F_x = -m\frac{v^2}{d}\cos\theta_1$$

Theta=.523

Fx=-5.4x10^{-8}kg $(1124\text{m/s})^2$/.56m cos(.523) = -.105 N

3) What is F_y, the y-component of the force on the particle at a time t_1 = 260.7 μs after it entered the region containing the magnetic field. Theta=.523

$$F_y = -m\frac{v^2}{d}\sin\theta_1$$

Fy=-5.4x10^{-8}kg (1124m/s)^2/2*.56m sin(.523)= -.061 N

4) What is q, the charge of the particle? Be sure to include the correct sign.

$$d = \frac{mv}{qB} \Rightarrow q = -\frac{mv}{dB}$$

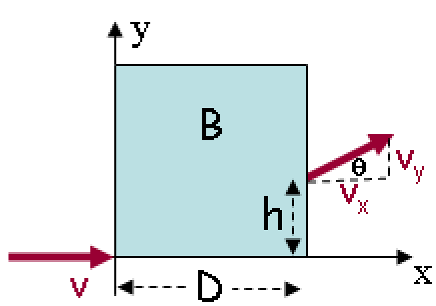
q=-5.4x10^{-6}kg 1124 m/s/(.56 m 2.6T) =-41.6 uC

5) If the velocity of the incident charged particle were doubled, how would B have to change (keeping all other parameters constant) to keep the trajectory of the particle the same?

Looking at the equation above for d, if v->2v, then B must also ->2B so the 2s will cancel top and bottom and keep d the same.

Feedback:
Your answer is correct! If the velocity were doubled, the radius of curvature would double. Since the radius of curvature is inversely proportional to the magnetic field strength, if we then double the magnetic field strength, the radius of curvature woudl be halved, bringing it back to its original value.

A proton (q = 1.6 X 10^{-19} C, m = 1.67 X 10^{-27} kg) moving with constant velocity enters a region containing a constant magnetic field that is directed along the z-axis at (x,y) = (0,0) as shown. The magnetic field extends for a distance D = 0.61 m in the x-direction. The proton leaves the field having a velocity vector (v_x, v_y) = (5.7 X 10^5 m/s, 2.3 X 10^5 m/s).



1) What is v, the magnitude of the velocity of the proton as it entered the region containing the magnetic field?

$$v = \sqrt{v_x^2 + v_y^2}$$

V=((5.7 X 10^5 m/s)^2+ (2.3 X 10^5 m/s)^2)$^{1/2}$=6.14x10^5m/s

2) What is R, the radius of curvature of the motion of the proton while it is in the region containing the magnetic field?

$$\sin\theta = \frac{v_y}{v} \qquad \Longrightarrow \qquad R = \frac{D}{\sin\theta} = D\frac{v}{v_y}$$

$$\frac{D}{R} = \sin\theta$$

R=.61 m 6.1x10^5/2.3x10^5=1.63 m

3) What is h, the y co-ordinate of the proton as it leaves the region conating the magnetic field?

$$h = R - R\cos\theta = R(1-\cos\theta)$$

$$\tan\theta = \frac{\sqrt{1-\cos^2\theta}}{\cos\theta} = \frac{v_y}{v_x} \qquad \Longrightarrow \qquad \cos\theta = \frac{v_x}{\sqrt{v_x^2 + v_y^2}}$$

Cosθ=5.7/6.14=.93

h=1.63m(1-2.47)=-.118m

4) What is B_z, the z-component of the magnetic field? Note that B_z is a signed number.

$$R = \frac{mv}{qB} \qquad \Longrightarrow \qquad B = \frac{mv}{qR} \qquad \Longrightarrow \qquad B_z = -\frac{mv}{qR}$$

Bz=-1.67x10^{-27}kg 6.1x10^5m/s/(1.6x10-^{19} C 1.63 m)=-.0039T

5) If the incident velocity v were increased, how would h and θ change, if at all?

Look at the eqn from 4, R is proportional to v. Looking at the diagram, you can see that if the angle is smaller so is h.

6) Your answer is correct! If the velocity were increased, the radius of curvature would increase by the same factor since R is proportional to v. If the radius of curvature increases, the angle through which the particle bends in a distance D also decreases. If the angle decreases, then the displacement h also decreases.