(a). A physicist shoots protons with a velocity $v = 1 \times 10^7$ m/s into a region with a constant magnetic field, $B = 1$ T, as shown. Which of the two paths shown (A) or (B) does the proton follow? What is the distance from where the proton enter the field region (the point "in") to where they exit (the point "out")? [3 points]

By right hand rule, path $B$

Distance $2r$ where $r$ is radius of circular orbit:

$$F_B = F_c$$
$$qvB = m \frac{v^2}{r}$$
$$r = \frac{mv}{qB}$$

$$\text{Distance} = 2r = \frac{2mv}{qB} = 0.20 \text{ cm}$$

(b). Annoyed with being struck by his own protons, the physicist adds an electric field so that the protons continue to travel in a straight line in the region with magnetic field. What is the magnitude and direction of this electric field? [2 points]

Apply downward field: $\vec{F}_B \uparrow qvB$ $\vec{F}_E \downarrow qE$

$qvB = qE$

$$E = UB = 1 \times 10^7 \text{ V/m}$$

(over)
2. (a) Two crossed wires each have a current $I=1$ A flowing as shown. What is the magnitude and direction of the magnetic field at the point $A$? [3 points]

Let $r_1 = 0.1$ m, $r_2 = 0.2$ m.

\[ B_1 = \frac{\mu_0 I}{2\pi r_1} \hat{r}, \quad \text{out of page} \]

\[ B_2 = \frac{\mu_0 I}{2\pi r_2} \hat{r}, \quad \text{into page} \]

\[ B_{\text{total}} = B_1 - B_2 = \frac{\mu_0 I}{2\pi} \left( \frac{1}{r_1} - \frac{1}{r_2} \right) \]

\[ = 2 \cdot 10^{-6} \, \text{T} - 1 \cdot 10^{-6} \, \text{T} \]

\[ B = 1 \cdot 10^{-6} \, \text{T} \quad \text{out of page} \]

(b). On the figure, draw the direction of the force exerted on wire 2 by wire 1 at the points C and D. [2 points]

A+ C: \[ \uparrow \vec{F} \]

A+ D: \[ \uparrow \vec{F} \]

**Rewrite and sign the honor pledge:** "I pledge my honor that I have not violated the Honor Code during this examination.

Signature__________________________