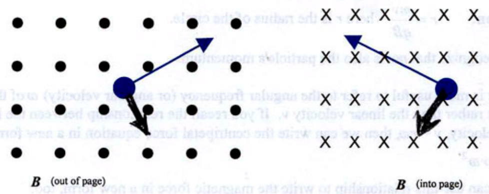
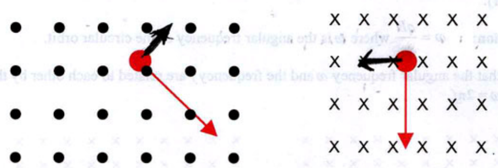
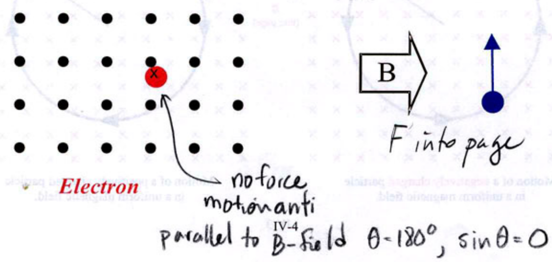
Your Name _______________

Practice Problem 4.1:
Which way does it go?

In each situation, a charged particle (blue = positive, red = negative) has an initial trajectory in a magnetic field. Draw a **FORCE vector** (arrow) to indicate which way the magnetic force acts on this particle. (Start on the dot.) Be careful of the signs and use your RHR!







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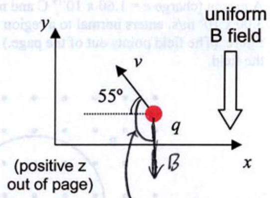
Practice Problem #4.2:
More fun with particles and fields...

A **negatively** charged particle with charge $q = -3.2\ \mu C$, travels in the *x-y* plane through a region of uniform magnetic field. The *B* field has magnitude 3.33 mT, and points in the negative *y* direction. At a particular moment in time (shown in the figure), the particle's trajectory makes an angle of 55° with the negative *x*-axis, and its velocity *v* is 4.5×10^5 m/s.



What is the *z* component of the force *F* on the **negatively** charged object?

$\theta = 55 + 90 = 145°$

neg chg → force into page

$|F| = |q| \cdot |v| \cdot |B| \cdot \sin\theta \qquad \sin 145° = 0.574$

$= (3.2 \cdot 10^{-6}\ C)(4.5 \cdot 10^{5}\ m/s)(3.33 \cdot 10^{-3}\ T)(0.574)$

$= 2.75 \cdot 10^{-3}\ N$

$$\boxed{F_z = -2.75 \cdot 10^{-3}\ N}$$

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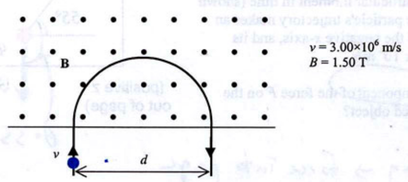
Practice Problem #4.3:
Even more fun with particles and fields...

A proton (charge $e = 1.60 \times 10^{-19}$ C and mass $m = 1.67 \times 10^{-27}$ kg), travelling with speed $v = 3.00 \times 10^6$ m/s, enters normal to a region of uniform magnetic field $B = 1.50$ T as shown in the figure. (The field points out of the page.) After completing a semicircular path, the proton exits the field.



a) Calculate the spacing d between the entrance and exit points on the proton's trajectory.

$$\text{spacing } d = 2R_c = \frac{2mv}{qB} = \frac{2\cdot(1.67\cdot10^{-27}c)(3\cdot10^{6}\frac{m}{s})}{(1.6\cdot10^{-19}C)(1.5T)}$$

$$= 4.175\cdot10^{-2}\ m$$

b) Calculate the **amount of time** Δt the proton spends inside the magnetic field.

$$\Delta t = \frac{\text{Path length}}{\text{speed}}$$

$$= \frac{(\pi/2)d}{v} = \frac{\pi}{2}\cdot\frac{2mv}{qB}\cdot\frac{1}{v}$$

$$= \frac{\pi m}{qB} = 2.186\cdot10^{-8}\ sec$$

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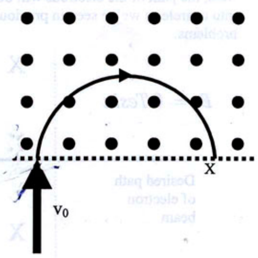
Practice Problem #4.4:
Particles in Magnetic Fields

a). A positively charged particle is injected into a region occupied by a uniform B field pointing out of the paper. The particle's initial velocity v_0 is straight upward. It emerges from the B field region at position X after travelling for a time Δt through the field. If the particle was injected instead with velocity $2v_0$, it would:

i) emerge at the same position X, but after a different amount of time $\Delta t'$.

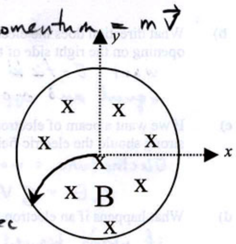
ii) emerge at a different position X′, but after the same amount of time Δt.

iii) emerge at a different position X′, and after a different amount of time $\Delta t'$.



b) A charged particle ($q = 1.6 \times 10^{-19}$ C) is emitted from the origin. It moves in the x-y plane. A uniform magnetic field B = 0.5 T points in the negative z direction. The trajectory traced out by the particle is a circle with radius $R = 55$ cm. Calculate the magnitude of the momentum of the particle.

$R = \frac{m|\vec{v}|}{qB} = \frac{|\vec{P}|}{qB}$ $\vec{P}$ is momentum $= m\vec{v}$



$|\vec{P}| = qBR$

$= 1.6 \cdot 10^{-19} \cdot 0.5 \cdot 0.55$

$= 4.4 \cdot 10^{-20}$ kg·meter/sec

units of momentum are mass times velocity

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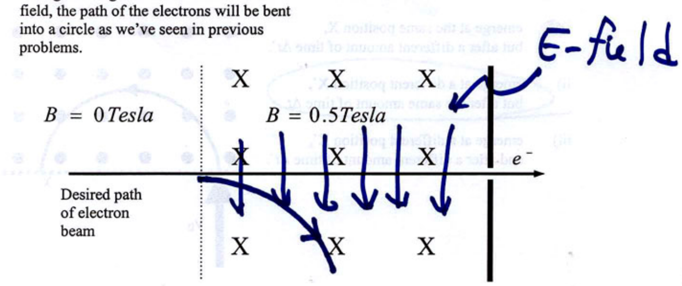
Practice Problem #4.5:
Practical Application: velocity selector

A uniform magnetic field of 0.5 Tesla into the page is applied in the region shown below. A beam of electrons is directed through the region. Without an electric field, the path of the electrons will be bent into a circle as we've seen in previous problems.

$Q = -1.602 \times 10^{-19}\ Coulombs$

$m_e = 9.109 \times 10^{-31}\ kg$



a) What direction will the electron beam bend when only the magnetic field is present? Draw in an example trajectory on the picture above.

down ward in picture

b) What direction does the electric field need to point for the electron beam to exit the opening on the right side of the drawing? Show this on the picture above.

want E-field to give force in up direction equal and opposite to force from B-field. Points down

c) If we want a beam of electrons with a velocity of 600 m/s to exit the right side, how strong should the electric field be?

Electric force = magnetic force ($\theta = 90°$)

$qE = qvB \rightarrow E = vB = 600 \cdot 0.5\ \frac{V}{m} = 300\ \frac{V}{m}$

d) What happens if an electron in the beam does not match this speed?

it won't travel a straight line - too slow (go up) - too fast (go down)

e) What would change in questions a) - d) if the charge is positive and all other properties (mass, magnetic field and velocity) are the same?

a) deflect upward b) no change, c) no change

d) slow charge goes down, fast charge goes up.