Unit Exam III: Problem #1 (Spring '12)

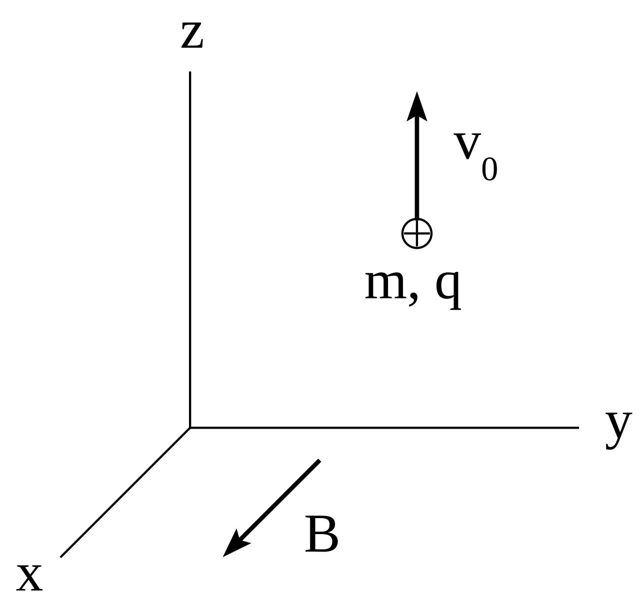
In a region of uniform magnetic field $\mathbf{B} = 5\mathrm{mT}\hat{\mathbf{i}}$, a proton $(m = 1.67 \times 10^{-27}\mathrm{kg},\ q = 1.60 \times 10^{-19}\mathrm{C})$ is launched with velocity $\mathbf{v}_0 = 4000\mathrm{m/s}\hat{\mathbf{k}}$.

(a) Calculate the magnitude F of the magnetic force that keeps the proton on a circular path.

(b) Calculate the radius r of the circular path.

(c) Calculate the time T it takes the proton to go around that circle once.

(d) Sketch the circular path of the proton in the graph.



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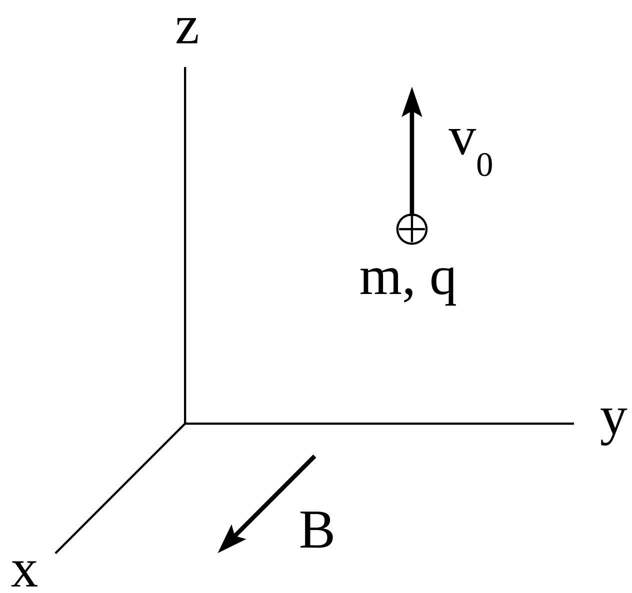


Solution:

(a) $F = qv_0B = 3.2 \times 10^{-18}\mathrm{N}.$

(b) $\dfrac{mv_0^2}{r} = qv_0B \quad \Rightarrow\ r = \dfrac{mv_0}{qB} = 8.35\mathrm{mm}.$

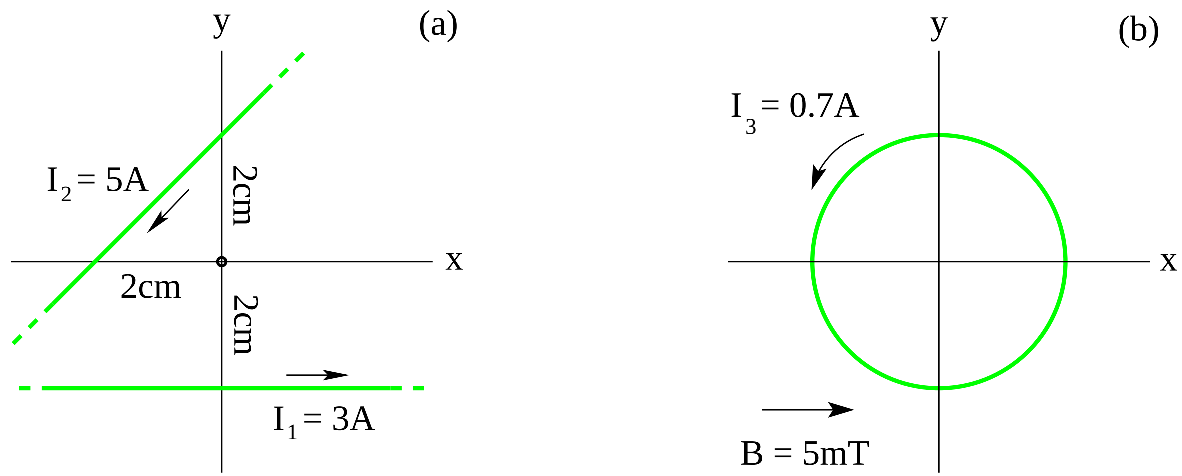
(c) $T = \dfrac{2\pi r}{v_0} = \dfrac{2\pi m}{qB} = 13.1\mu\mathrm{s}.$

(d) Center of circle to the right of proton's initial position (cw motion).

Unit Exam III: Problem #2 (Spring '12)

(a) Two very long straight wires positioned in the xy-plane carry electric currents I_1, I_2 as shown. Calculate magnitude (B_1, B_2) and direction $(\odot, \otimes)$ of the magnetic field produced by each current at the origin of the coordinate system.

(b) A conducting loop of radius $r = 3$cm placed in the xy-plane carries a current $I_3 = 0.7$A in the direction shown. Find direction and magnitude of the torque $\vec{\tau}$ acting on the loop if it is placed in a magnetic field $\mathbf{B} = 5\mathrm{mT}\hat{\mathbf{i}}$.



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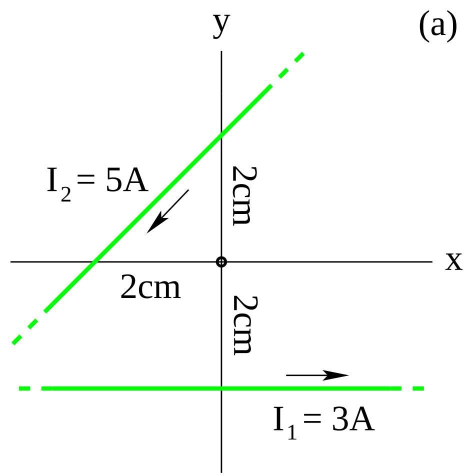
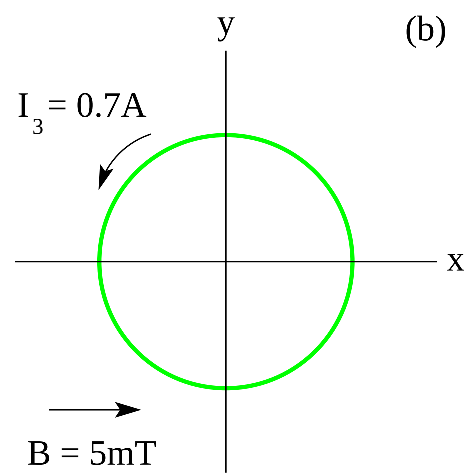




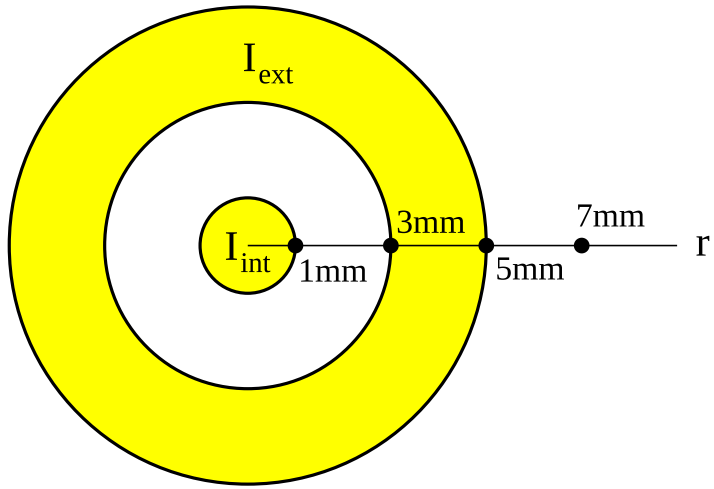
Solution:

(a) $B_1 = \dfrac{\mu_0(3\mathrm{A})}{2\pi(2\mathrm{cm})} = 30\mu\mathrm{T}. \quad \odot \qquad B_2 = \dfrac{\mu_0(5\mathrm{A})}{2\pi(1.41\mathrm{cm})} = 70.9\mu\mathrm{T}. \quad \odot$

(b) $\vec{\mu} = \pi(3\mathrm{cm})^2(0.7\mathrm{A})\hat{\mathbf{k}} = 1.98 \times 10^{-3}\mathrm{Am}^2\hat{\mathbf{k}} \quad \Rightarrow \quad \vec{\tau} = \vec{\mu} \times \mathbf{B} = 9.90 \times 10^{-6}\mathrm{Nm}\hat{\mathbf{j}}.$

Unit Exam III: Problem #3 (Spring ’12)

The coaxial cable shown in cross section has surfaces at radii 1mm, 3mm, and 5mm. Equal currents flow through both conductors: $I_{int} = I_{ext} = 0.03\text{A}$ $\odot$ (out). Find direction $(\uparrow, \downarrow)$ and magnitude (B_1, B_3, B_5, B_7) of the magnetic field at the four radii indicated ($\bullet$).



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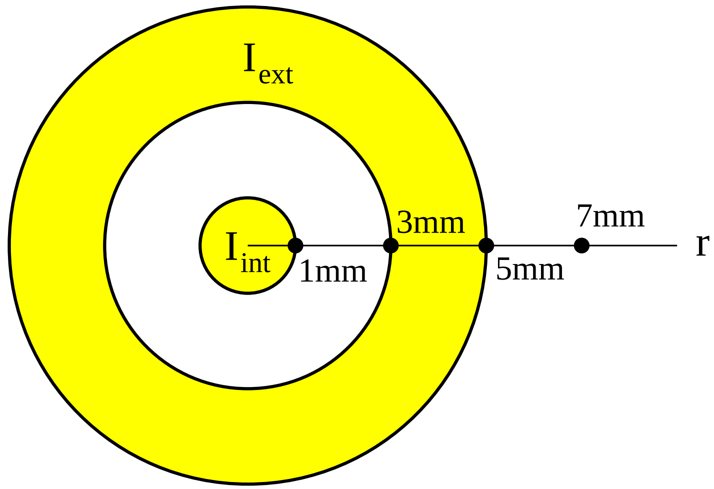

Solution:

$$2\pi(1\text{mm})B_1 = \mu_0(0.03\text{A}) \quad \Rightarrow \quad B_1 = 6\mu\text{T} \quad \uparrow$$

$$2\pi(3\text{mm})B_1 = \mu_0(0.03\text{A}) \quad \Rightarrow \quad B_1 = 2\mu\text{T} \quad \uparrow$$

$$2\pi(5\text{mm})B_1 = \mu_0(0.06\text{A}) \quad \Rightarrow \quad B_1 = 2.4\mu\text{T} \quad \uparrow$$

$$2\pi(7\text{mm})B_1 = \mu_0(0.06\text{A}) \quad \Rightarrow \quad B_1 = 1.71\mu\text{T} \quad \uparrow$$