Name____

Physics 121 Quiz #6, March 2, 2018

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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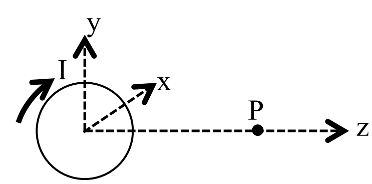
1. A segment of wire of length $L = 15cm$ with has a current $I = 3A$ flowing from left to right across the page. At a point $6cm$ below the wire the midpoint of the wire, what is the magnetic field?

$$\left|\vec{B}_{wire}\right| = \frac{\mu_o LI}{4\pi r\sqrt{\left(\frac{L}{2}\right)^2 + r^2}} = \frac{4\pi \times 10^{-7}\,\frac{Tm}{A} \times 0.15m \times 3A}{4\pi\left(0.06m\right)\sqrt{\left(0.075m\right)^2 + \left(0.06m\right)^2}} = 7.8 \times 10^{-6}\,T$$

Directed into the plane of the page by the right-hand rule.

2. Suppose that you have a $N = 300$ turn circular coil of wire with radius $R = 20cm$. The coil of wire is oriented in the x-y plane with the axis of the coil pointing along the z-direction. If a current of $I = 1A$ is flowing clockwise (as viewed looking along the –z-direction toward the coil, what is the magnetic field at a point $P = \langle 0,0,20\rangle cm$? The coil of wire and its orientation are shown on the right.



$$\left|\vec{B}_{ring}\right| = \frac{\mu_o NIR^2}{2\left(z^2 + R^2\right)^{\frac{3}{2}}} = \frac{4\pi \times 10^{-7}\,\frac{Tm}{A} \times 300 \times 1A \times \left(0.2m\right)^2}{2\left(\left(0.2m\right)^2 + \left(0.2m\right)^2\right)^{\frac{3}{2}}} = 3.33 \times 10^{-4}\,T$$

$$\vec{B} = \langle 0,0,-3.33\rangle \times 10^{-4}\,T$$

3. Suppose that a charge $q=+e$ were directed toward point $P=\langle 0,0,20\rangle cm$ with a velocity $\vec{v}=\langle -2,0,0\rangle\times 10^5 \frac{m}{s}$. What magnetic force would the charge experience at point P?

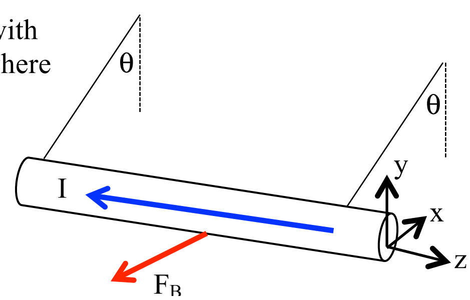
$$\vec{F}=q\vec{v}\times\vec{B}=\begin{vmatrix} i & j & k \\ -ev & 0 & 0 \\ 0 & 0 & -B \end{vmatrix}=\langle 0,-evB,0\rangle=\langle 0,1.07,0\rangle\times 10^{-17}N$$

$$F_y=evB=1.6\times 10^{-19}\times 2\times 10^5 \tfrac{m}{s}\times 3.33\times 10^{-4}T=1.07\times 10^{-17}N$$

4. Suppose that instead of the charge q, you had a very short segment of wire of length L, where $L<<20cm$, centered on point $P=\langle 0,0,20\rangle cm$ with a curent I flowing along the –z-axis. What magnetic force would the wire feel due to the magnetic field of the ring at point $P=\langle 0,0,20\rangle cm$?

$$\vec{F}=I\vec{L}\times\vec{B}=\begin{vmatrix} i & j & k \\ 0 & 0 & -IL \\ 0 & 0 & -B \end{vmatrix}=\langle 0,0,0\rangle N$$

5. Suppose that a segment of wire were suspended from the ceiling with strings of negligible mass. A magnetic field exists in the region where the wire is suspended. If a current I flows in the -z direction as shown in the diagram the wire will experience a magnetic force $\vec{F}$ that makes it swing through an angle θ measured with respect to the y-axis and comes to rest. What is the magnetic field that will produce this? Assume that the wire has a uniform mass density $\mu=\frac{m}{L}$.



a. $\vec{B}=\left\langle 0,\frac{\mu g}{I}\tan\theta,0\right\rangle$.

b. $\vec{B}=\left\langle 0,-\frac{\mu g}{I}\tan\theta,0\right\rangle$.

c. $\vec{B}=\left\langle -\frac{\mu g}{I}\tan\theta,0,0\right\rangle$.

d. $\vec{B}=\left\langle 0,0,-\frac{\mu g}{I}\tan\theta\right\rangle$.

e. None of the magnetic fields will produce this effect.

Physics 121 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r};\ \ \hat{r} = \frac{\vec{r}_o - \vec{r}_s}{\left|\vec{r}_o - \vec{r}_s\right|}$$

$$\vec{E} = \frac{\vec{F}}{q} = \int d\vec{E} = \int dE\hat{r} = \int \frac{kdq}{r^2}\hat{r}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$\left|\vec{E}_{\parallel}\right| = \frac{2kqs}{r^3};\ \text{dipole } r >> s$$

$$\left|\vec{E}_{\perp}\right| = \frac{kqs}{r^3};\ \text{dipole } r >> s$$

$$\left|\vec{E}_{rod}\right|_{\perp} = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r\sqrt{r^2 + \left(L/2\right)^2}}\right]$$

$$\left|\vec{E}_{rod}\right|_{\parallel} = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r\left(L+r\right)}\right];\ \left|\vec{E}_{rod}\right|_{\parallel} \sim \frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{rL}\right)\ \ L >> r$$

$$\left|\vec{E}_{ring}\right| = \frac{1}{4\pi\varepsilon_0}\left[\frac{Qz}{\left(R^2+z^2\right)^{\frac{3}{2}}}\right]$$

$$\left|\vec{E}_{disk}\right| = \frac{Q}{2\pi\varepsilon_0 R^2}\left[1 - \frac{z}{\sqrt{R^2+z^2}}\right];\ \ \left|\vec{E}_{disk}\right| \sim \frac{Q}{2\varepsilon_0 A}\left[1 - \frac{z}{R}\right]\ \ z << R;\ \ \left|\vec{E}_{disk}\right| \sim \frac{Q}{2\varepsilon_0 A}\ \ z << R$$

$$\left|\vec{E}_{capacitor}\right| \sim \frac{Q}{\varepsilon_0 A};\ \ \left|\vec{E}_{fringe}\right| \sim \frac{Q}{2\varepsilon_0 A}\left(\frac{s}{R}\right)$$

$$W = -q\Delta V = -\Delta U = \Delta K;\ \ U = \sum_{i \neq j}\frac{kQ_iQ_j}{r_{ij}};$$

$$V_Q = \frac{kQ}{r};\ \ V_{Q's} = \sum_i \frac{kQ_i}{r_i}$$

$$\Delta V = -\int \vec{E}\cdot d\vec{r}$$

$$E_x = -\frac{\Delta V}{\Delta x};\ \ E_y = -\frac{\Delta V}{\Delta y};\ \ E_z = -\frac{\Delta V}{\Delta z};\ \ \vec{E} = -\left\langle \frac{dV}{dx}, \frac{dV}{dy}, \frac{dV}{dz}\right\rangle$$

$$Q = \left(\frac{\kappa\varepsilon_0 A}{s}\right)\Delta V$$

$$U = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$

$$Q = Q_{\max}\left(1 - e^{-\frac{t}{RC}}\right);\ \ Q = Q_{\max}e^{-\frac{t}{RC}}$$

$$I = \frac{dQ}{dt} = n\left|e\right|Av_d = \int \vec{J}\cdot d\vec{A}$$

$$n = \frac{\rho}{M}N_A$$

$$\vec{J} = n\left|e\right|\vec{v}_d = \sigma\vec{E} = \tfrac{1}{\rho}\vec{E} \rightarrow V = IR;\ R = \frac{\rho L}{A}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$\rho = \rho_0\left(1 + \alpha\Delta T\right)$$

$$\vec{F} = q\vec{v}\times\vec{B};\ \left|\vec{F}\right| = qvB\sin\theta$$

$$\vec{B} = \frac{\mu_o}{4\pi}\left(\frac{q\vec{v}\times\hat{r}}{r^2}\right)$$

$$d\vec{B} = \frac{\mu_o I}{4\pi}\left(\frac{d\vec{l}\times\hat{r}}{r^2}\right)$$

$$\left|\vec{B}_{wire}\right| = \frac{\mu_o LI}{4\pi r\sqrt{\left(\frac{L}{2}\right)^2 + r^2}};\ \ \left|\vec{B}_{wire}\right| \approx \frac{\mu_o I}{2\pi r}\ \ L >> r$$

$$\left|\vec{B}_{ring}\right| = \frac{\mu_o IR^2}{2\left(z^2+R^2\right)^{\frac{3}{2}}};\ \left|\vec{B}_{ring}\right| \approx \frac{\mu_o IR^2}{2z^3}\ \ z << R$$

$$\vec{F} = I\vec{L}\times\vec{B};\ \left|\vec{F}\right| = ILB\sin\theta$$

$$\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}$$

$$R_{eq} = \sum_i R_i$$

$$C_{eq} = \sum_i C_i$$

$$\frac{1}{C_{eq}} = \sum_i \frac{1}{C_i}$$

Constants

$$g = 9.8\,\tfrac{m}{s^2}$$

$$1e = 1.6\times10^{-19}C$$

$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\,\tfrac{Nm^2}{C^2}$$

$$\varepsilon_o = 8.85\times10^{-12}\,\tfrac{C^2}{Nm^2}$$

$$1eV = 1.6\times10^{-19}J$$

$$\mu_o = 4\pi\times10^{-7}\,\tfrac{Tm}{A}$$

$$c = 3\times10^8\,\tfrac{m}{s}$$

$$h = 6.63\times10^{-34}Js$$

$$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$$

$$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$$

$$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$$

$$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$$

$$N_A = 6.02\times10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$$