Name_______________________________________

Physics 111 Quiz #3, October 9, 2020

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 charge $+q$ (and mass m) is accelerated, from rest, through a potential difference V aquiring a velocity $\vec{v}$ to the right across the page as shown below. The charge $+q$ then enters a region of uniform magnetic field $\vec{B}$ oriented perpendicular to the velocity of the charge and pointing out of the page. When the charge enters the magnetic field its motion will most likely approximate which of the following?

    a. A circle of radius R down the page.

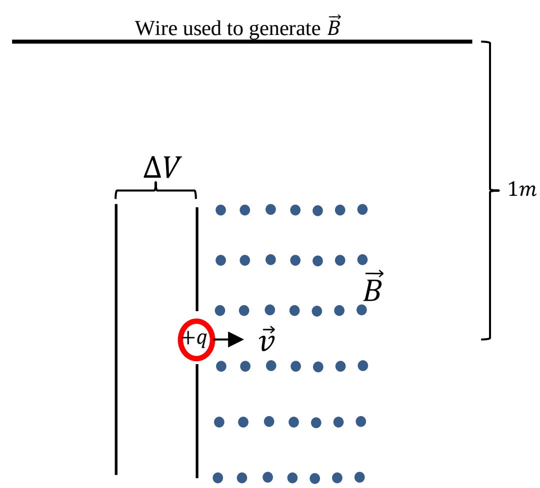
    b. A helix of radius R down and out of the page.

    c. A helix of radius R up and into the page.

    d. A circle of radius R up the page

    e. A straight line as the charge is unaffected by the magnetic field.

2. Suppose that the magnetic field were generated by a long straight wire in the plane of the paper located $1m$ away as shown on the right. What magnitude and direction of current flowing in the wire would be needed to generate a $6.2\mu T$ magnetic field $1m$ away from the wire?



To get the magnetic field to point out of the page we need the current to flow from right to left across the page.

$$B = \frac{\mu_o I}{2\pi r} \rightarrow I = \frac{2\pi r B}{\mu_0} = \frac{2\pi \times 1m \times 6.2\times 10^{-6} T}{4\pi \times 10^{-7}\frac{Tm}{A}} = 31A$$

3. Suppose the wire were made out of gold ($\rho_{Au} = 19300\frac{kg}{m^3}; m = 197g$) with a length $L = 5m$ and diameter $4mm$. What would be the drift speed of charge carriers in the gold wire if gold donates one charge carrier per atom?

$$I = neAv_d \rightarrow v_d = \frac{I}{neA} = \frac{31A}{5.9\times10^{28}\frac{charge\ carrier}{m^3}\times1.6\times10^{-19}\frac{C}{charge\ carrier}\times\pi(2\times10^{-3}m)^2} = 2.6\times10^{-4}\frac{m}{s}$$

Where, $n = \frac{\rho}{m}N_A = \frac{19300\frac{kg}{m^3}}{0.197\frac{kg}{mol}}\times 6.02\times10^{23}\frac{atoms}{mol}\times\frac{1\ charge\ carrier}{atom} = 5.9\times10^{28}\frac{charge\ carrier}{m^3}$

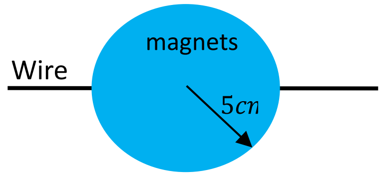
4. Suppose that you wanted this charge $q = +3e$ (and mass $m = 7m_p$) to travel in a circle of radius $R = 40cm$ through the magnetic field. What potential difference V would be required to accelerate the charge?

$$F = qvB = m\frac{v^2}{R} \rightarrow \left(\frac{qRB}{m}\right)^2 = v^2$$

$$W = -q\Delta V = qV = \frac{1}{2}mv^2 \rightarrow v^2 = \frac{2qV}{m}$$

$$v^2 = \frac{2qV}{m} = \frac{q^2R^2B^2}{m^2} \rightarrow V = \frac{qR^2B^2}{2m} = \frac{3\times1.6\times10^{-19}C\times(0.4m)^2(6.2\times10^{-6}T)^2}{2\times7\times1.67\times10^{-27}kg} = 1.3\times10^{-4}V = 0.1mV$$

5. Instead of the situation above, suppose that you placed the wire (the one producing the magnetic field) in between the circular poles of a magnet with radius $r = 5cm$ as shown below. What magnetic field (magnitude and direction) would be needed for the wire to feel a magnetic force of $3N$ directed up the page? Assume that $\vec{v}_d$is perpendicular to the external magnetic field and the current you calculated in part 2 is flowing in the wire.



For the force up the page and the current flowing to the left, the magnetic field would point out of the page from the lower to the upper magnet.

The magnetic field: $F = ILB \rightarrow B = \frac{F}{IL} = \frac{3N}{31A\times0.1m} = 0.97T$

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1 Q_2}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

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

$$PE = k\frac{Q_1 Q_2}{r}$$

$$V(r) = k\frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$\tau = NIAB\sin\theta = \mu B\sin\theta$$

$$PE = -\mu B\cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

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

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

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

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

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

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

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

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

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

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

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

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

$N_A = 6.02\times10^{23}$

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

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t} = neAv_d$$

$$V = IR = I\left(\frac{\rho L}{A}\right)$$

$$R_{series} = \sum_{i=1}^{N} R_i$$

$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$

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

$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$

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

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

$$Q_{\text{discharge}}(t) = Q_{\max}e^{-\frac{t}{RC}}$$

$$C_{parallel} = \sum_{i=1}^{N} C_i$$

$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{\max} = hf - \phi = eV_{stop}$$

$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2c^2 + m^2c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

Geometry

Circles $C = 2\pi r = \pi D \qquad A = \pi r^2$

Triangles $A = \frac{1}{2}bh$

Spheres $A = 4\pi r^2 \qquad V = \frac{4}{3}\pi r^3$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$

$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_o}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_o}$$

$$P = \frac{S}{c} = \frac{Force}{Area}$$

$$S = S_o\cos^2\theta$$

$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$

$$\theta_{inc} = \theta_{refl}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \prod_{i=1}^{N} M_i$$

$$S_{out} = S_{in}e^{-\sum_i \mu x_i}$$

$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$

$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$

$$PE_{gravity} = mgy$$

$$PE_{spring} = \tfrac{1}{2}ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$