Name____

Physics 111 Quiz #4, February 12, 2021

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 charged particle of unknown mass (and charge) undergoes helical motion in a magnetic field. The motion of the charged particle is such that it has an orbital diameter perpendicular to the magnetic field of $D = 0.35m$ and the pitch of its motion is $l = 0.42m$? At what angle θ to the magnetic field was the velocity vector of the charged particle?

$$v_{\parallel} = v\ \cos\theta = \frac{l}{T}$$

$$v_{\perp} = v\ \sin\theta = \frac{2\pi R}{T}$$

$$\frac{v_{\perp}}{v_{\parallel}} = \frac{v\sin\theta}{v\cos\theta} = \tan\theta = \frac{2\pi R}{l} = \frac{2\pi \times \left(\frac{0.35m}{2}\right)}{0.42m} \to \theta = 69^0$$

2. Suppose that the speed of the charged particle and that the magnetic field strength was $v = 2 \times 10^7 \frac{m}{s}$ and $B = 5 \times 10^{-5} T$ respectively. What was the charge-to-mass ratio of the particle?

$$F = qv_{\perp}B = m\frac{v_{\perp}^2}{R} \to \frac{q}{m} = \frac{v_{\perp}}{RB} = \frac{v\sin\theta}{RB} = \frac{2 \times 10^7 \frac{m}{s} \sin 69}{\left(\frac{0.35m}{2}\right) 5 \times 10^5 T} = 2.1 \times 10^{12} \frac{C}{kg}$$

3. What was the orbital period of the charged particle about the magnetic field?

$$v_{\perp} = v\ \sin\theta = \frac{2\pi R}{T} \to T = \frac{2\pi R}{v\sin\theta} = \frac{2\pi \times \left(\frac{0.35m}{2}\right)}{2 \times 10^7 \frac{m}{s} \sin 69} = 5.9 \times 10^{-8} s$$

Or

$$v_{\parallel} = v\ \cos\theta = \frac{l}{T} \to T = \frac{l}{v\cos\theta} = \frac{0.42m}{2 \times 10^7 \frac{m}{s} \cos 69} = 5.9 \times 10^{-8} s$$

4. Through what potential difference would the charged particle have to be accelerated in order for it to acquire a speed of $v = 2 \times 10^7 \frac{m}{s}$? Assume that the particle started from rest.

$$W = -q\Delta V = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}mv^2$$

$$\rightarrow \Delta V = -\frac{m}{2q}v^2 = -\frac{1}{2 \times 2.1 \times 10^{12}\frac{C}{kg}}\left(2 \times 10^7 \frac{m}{s}\right)^2 = -93.7V$$

5. A segment of a wire (with diameter D) is situated between the poles of a magnet of length L. The wire segment is connected to a battery and a resistor so that a current is generated in the wire. The top view is looking down from the N pole of the magnet to the S pole of a second identical magnet while the side view is looking down the direction of the current. Which of the following statements is true about the wire?

   a. As viewed from above, the left-hand side of the wire would become positively charged.

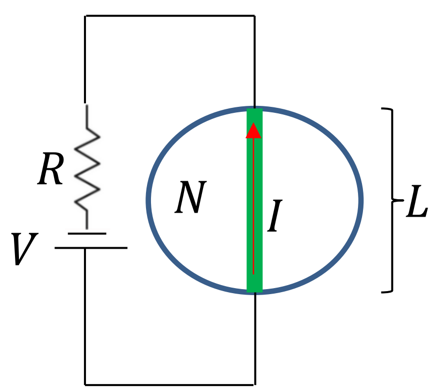
   b. As viewed from above, the right-hand side of the wire would become negatively charged.

   c. As viewed from above, an electric field (pointing from left to right) is generated perpendicular to the current across the wire.

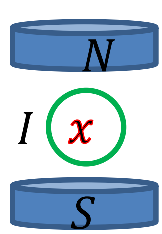
   d. As viewed from above, a potential difference is generated across the diameter of the wire.

   e. All of the above statements are true.

   f. None of the above statements are true.



Top view



Side view

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r}$$
$$\vec{E} = \frac{\vec{F}}{q}$$
$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$
$$PE = k\frac{Q_1Q_2}{r}$$
$$V(r) = k\frac{Q}{r}$$
$$E_x = -\frac{\Delta V}{\Delta x}$$
$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$
$$F = I l B\sin\theta$$
$$\tau = NIAB\sin\theta = \mu B\sin\theta$$
$$PE = -\mu B\cos\theta$$
$$B = \frac{\mu_0 I}{2\pi r}$$
$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

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

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

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

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

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

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

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

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

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

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

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

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

$N_A = 6.02\times10^{23}$

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

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$
$$V = IR = I\left(\frac{\rho L}{A}\right)$$
$$R_{series} = \sum_{i=1}^{N} R_i$$
$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$
$$P = IV = I^2R = \frac{V^2}{R}$$
$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$
$$PE = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$
$$Q_{\text{charge}}(t) = Q_{\max}\left(1-e^{-\frac{t}{RC}}\right)$$
$$Q_{\text{discharge}}(t) = Q_{\max}e^{-\frac{t}{RC}}$$
$$C_{parallel} = \sum_{i=1}^{N} C_i$$
$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

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 $A = \tfrac{1}{2}bh$

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

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$
$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$
$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$
$$P = \frac{S}{c} = \frac{Force}{Area}$$
$$S = S_o\cos^2\theta$$
$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$
$$\theta_{inc} = \theta_{refl}$$
$$n_1\sin\theta_1 = n_2\sin\theta_2$$
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$
$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$
$$M_{total} = \prod_{i=1}^{N} M_i$$
$$S_{out} = S_{in}e^{-\sum_i \mu x_i}$$
$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

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

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = m\vec{a}$$
$$\vec{F} = -k\vec{y}$$
$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$
$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$
$$PE_{gravity} = mgy$$
$$PE_{spring} = \tfrac{1}{2}ky^2$$
$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$
$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$
$$\vec{v}_f = \vec{v}_i + \vec{a}t$$
$$v_f^2 = v_i^2 + 2a\Delta x$$
$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$