Name_____

Physics 111 Quiz #3, October 6, 2017

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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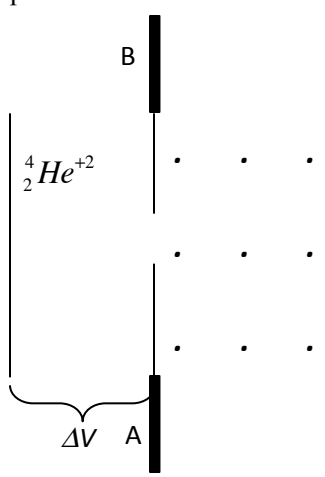
1. An alpha particle (${}^{4}_{2}He^{+2}$) is a helium nucleus with a mass approximately $4m_p$ and a charge of $+2e$. The alpha particle is accelerated through a potential difference of $\Delta V = 10000V$. The alpha particle enters a region of uniform magnetic field of strength $B = 0.6T$ and the alpha particle's velocity is perpendicular to the magnetic field as shown below. What detector (A or B) will the alpha particle strike and how far above or below the exit hole should that detector be placed so that the alpha particle can be detected?



$$F_B = qvB = ma = m\frac{v^2}{R}$$

$$R = \frac{mv}{qB} = \frac{m}{qB}\sqrt{\frac{2q\Delta V}{m}} = \sqrt{\frac{2m\Delta V}{qB^2}}$$

$$R = \sqrt{\frac{2\times 4\times 1.67\times 10^{-27}kg\times 10000V}{2\times 1.6\times 10^{-19}C\times (0.6T)^2}} = 0.033m$$

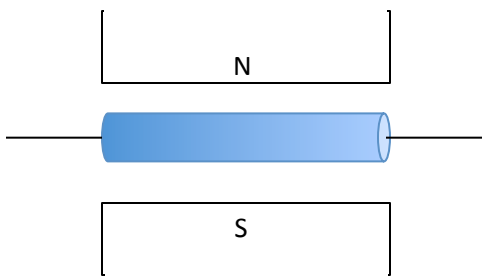
where the velocity is given by

$W = -q\Delta V = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2q\Delta V}{m}}$ and the distance

$D = 2R = 2\times 0.033m = 0.066m = 6.6cm$ is toward detector A.

2. Suppose that you had a mixture of helium ${}^{4}_{2}He^{+2}$ and zinc ${}^{65}_{30}Zn^{+2}$ nuclei and further suppose that the experimental parameters are kept constant for both nuclei. Where would you look to see the ${}^{65}_{30}Zn^{+2}$ nuclei?
   a. Look on the detector labeled A but closer to the exit hole than where the ${}^{4}_{2}He^{+2}$ would strike.
   b. Look on the detector labeled A but farther from the exit hole than where the ${}^{4}_{2}He^{+2}$ would strike.
   c. Look on the detector labeled B but closer to the exit hole than where the ${}^{4}_{2}He^{+2}$ would strike.
   d. Look on the detector labeled B but farther from the exit hole than where the ${}^{4}_{2}He^{+2}$ would strike.
   e. We are unable to determine where with respect to the exit hole and the ${}^{4}_{2}He^{+2}$ nuclei to tell where they would strike.

3. Suppose that a copper wire (with dimensions shown) is between the poles of a magnet of strength $B = 0.07T$ as shown below. The wire is made out of copper with the dimensions shown. There is an electron density of $8.5 \times 10^{28} \frac{e^+}{m^3}$ and the wire feels a force with magnitude $F = 0.04N$ when a current I flows through a resistor from a battery (both not shown). What is the drift speed of the electrons in the wire if the cross-sectional area of the wire is $A = 3.14 \times 10^{-6} m^2$ and the length of wire in the magnetic field is $L = 0.31m$?



$$F_B = ILB \rightarrow I = \frac{F_B}{LB} = \frac{0.04N}{0.31m \times 0.07T} = 1.8A$$

$$I = nAv_d q \rightarrow v_d = \frac{I}{nAq} = \frac{1.8A}{8.5 \times 10^{28} \frac{e^+}{m^3} \times 3.14 \times 10^{-6} m^2 \times 1.6 \times 10^{-19} C} = 4.2 \times 10^{-5} \frac{m}{s}$$

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

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$I = nAv_dq$$

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

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

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

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

Constants

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Electric Circuits

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

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

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

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

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

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

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

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

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

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

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

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

$$\text{Circles}: \quad C = 2\pi r = \pi D \qquad A = \pi r^2$$

$$\text{Triangles}: \quad A = \tfrac{1}{2}bh$$

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

Light as a Wave

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

$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

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

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