Name____

Physics 111 Quiz #1, January 13, 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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Two point charges are placed along the x-axis and are separated by a distance $x = 5cm$. The charge on the left is located at the origin and has a value of $q_L = +3\mu C$, while the charge on the right q_R is known to be positive but the magnitude of this charge is unknown.

1. It takes an external agent $8.7J$ worth of work to assemble the two charges in the given configuration. What is the magnitude of the 2nd unknown charge? Assume that each charge is brought in individually from very far away.

$$W = -q\Delta V = -Q_R\left[\frac{kQ_L}{r} - 0\right] = -\frac{kQ_RQ_L}{r} \rightarrow Q_R = -\frac{rW}{kQ_L}$$

$$Q_R = -\frac{0.05m \times (-8.7J)}{9\times10^9 \frac{Nm^2}{C^2} \times 3\times10^{-6}C} = 1.6\times10^{-5}C = 16\mu C$$

2. What is the electric field at a point midway between the two charges?

We choose the origin to be at the left most charge and selecting to the right to be the positive x-direction. Placing a positive test charge at the midpoint between the two charges, we have the electric field from the left most charge pointing to the right and the electric field from the right most charge pointing to the left.

$$E_{net} = E_L - E_R = \frac{kQ_L}{r^2} - \frac{kQ_R}{r^2} = \frac{k}{r^2}\left[Q_L - Q_R\right]$$

$$E_{net} = \frac{9\times10^9 \frac{Nm^2}{C^2}}{(0.025m)^2}\left[3-16\right]\times10^{-6}C = -1.87\times10^8 \frac{N}{C}$$

3. Suppose that an electron ($m_e = 9.11\times10^{-31}kg$) were placed at the midpoint between the two charges. If released from rest, what would be the initial acceleration?

$$F_{net} = ma_{net} = qE_{net} \rightarrow a_{net} = \frac{q}{m}E_{net}$$

$$a_{net} = \frac{-1.6\times10^{-19}C}{9.11\times10^{-31}kg}\left(-1.87\times10^{8}\,\tfrac{N}{C}\right)$$

$$a_{net} = 3.3\times10^{19}\,\tfrac{m}{s^2}$$

4. Suppose instead of the two charges above, you have two protons separated by a distance d. At the midpoint between the two protons, one places an electron at rest. The electron is given a small kick perpendicular to the line joining the two protons. The resulting motion of the electron would most likely be
   a. to move away from both protons along a line perpendicular to the line joining the two protons.
   b. to oscillate about a line perpendicular to the line joining the two protons.
   c. to move towards one of the two protons depending on the direction of the initial kick.
   d. to remain at rest.
   e. unable to be determined from the information given.

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

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Light as a Wave

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

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

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

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

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

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

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

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

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

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

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

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

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

Light as a Particle & Relativity

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

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

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

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

$$p = \gamma mv$$

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

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

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

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

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

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

Geometry

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

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

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