Name____

Physics 111 Quiz #1, January 7, 2010

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

1. Suppose that you wanted to be able to levitate yourself at a height of *1m* above the Earth's surface by placing an equal amount of charge on yourself and the Earth and using the repulsive electrostatic force to pick you up. If you have a mass of *70kg* about how much charge would you need to have put on yourself? (Assume the mass and radius of the Earth are $M_E = 6x10^{24}\ kg$ and $r_E = 6.4x10^6 m$ respectively.)

   a. *276 μC*

   b. *4.6 mC*

   $$mg = \frac{kQ^2}{r_E^2} \to Q = \sqrt{\frac{mgr_E^2}{k}} = 1764C \sim 1800C$$

   c. *1800 C*

   d. *There is no amount of charge that could accomplish this feat.*

2 A point charge $q_1 = -9\mu C$ is placed at x = 0, while another point charge $q_2 = 4\mu C$ is placed at x = 1m.

   a. At what point, measured with respect to q_1 and besides infinity, would the net force on a positive charge q_3 be zero? (Hint: you will need to solve a quadratic equation and the solutions are given by $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$)

   $$F_{net,3} = -F_{1,3} + F_{2,3} = -\frac{kQ_1Q_3}{r_{13}^2} + \frac{kQ_2Q_3}{r_{23}^2} = 0$$

   $$\frac{Q_1}{r_{13}^2} = \frac{Q_2}{r_{23}^2} \to \frac{Q_1}{d^2} = \frac{Q_2}{(d-1)^2} \to (Q_2 - Q_1)d^2 + 2Q_1 d - Q_1 = 0$$

   $$d = \begin{Bmatrix} 3.0m \\ 0.6m \end{Bmatrix}$$

   From a force diagram we chose the 3.0-m solution as the correct choice since the 0.6m choice produces two force vectors that point in the same direction..

   b. Does the actual value of q_3 matter when you calculate the positions that you can place the charge and what is the significance of the position value that you discarded in part a? Explain your answers.

   The actual charge for q_3 does not matter since the forces have to sum to zero. The solution that we discarded in part a, maybe a mathematical solution to the problem, but physically the force vectors at this second location point in the same direction and will not cancel to give a zero force. This spot would be physically correct if q_1 and q_2 had the same sign.

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r}$$

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

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

$$PE = k\frac{Q_1Q_2}{r}$$

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

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

$$W_{A,B} = q\Delta V_{A,B}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$N_A = 6.02\times10^{23}$

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

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

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

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

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

Light as a Wave

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

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

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

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

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

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

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

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

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

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

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

$$d\sin\theta = m\lambda \ \text{ or } \ (m+\tfrac{1}{2})\lambda$$

$$a\sin\phi = m'\lambda$$

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

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

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

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

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

$$PE_{gravity} = mgy$$

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