Name____

Physics 111 Quiz #1, September 19, 2014

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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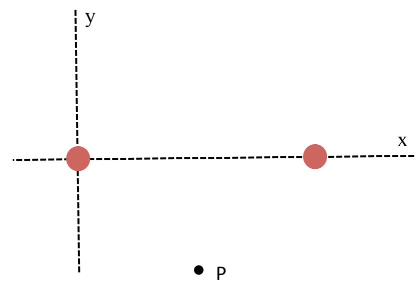
Two negative charges, each with magnitude $3\mu C$ are placed along the x-axis as shown in the diagram below. The two charges are spaced by a distance of $1m$.



1. What is the net electric field the point P located at $(x,y)=(0.5,-0.5)m$ shown on the diagram?

By the symmetry in the problem the horizontal component of the net electric field vanishes. Thus the net electric field points in the positive y-direction with a magnitude given by:

$E_{net} = E_{net,y} = 2\frac{kQ}{r^2}\sin\theta = \frac{2\times 9\times 10^9 \frac{Nm^2}{C^2}\times 3\times 10^{-6}C}{(0.707m)^2}\left[\frac{0.5m}{0.7m}\right] = 7.64\times 10^4 \frac{N}{C}$. The distance between the point and the charge is given by $r=\sqrt{x^2+y^2}=\sqrt{(0.5m)^2+(0.5m)^2}=0.707m$.

2. What is the electric potential at point P?

The electric potential at point P is given by the sum of the potentials due to each charge. Thus

$$V_P = -2\frac{kQ}{r} = -\frac{2\times 9\times 10^9 \frac{Nm^2}{C^2}\times 3\times 10^{-6}C}{0.707m} = -7.64\times 10^4 V$$

3. If a charge of $q = 3\mu C$ were placed at point P, what is the net force on this charge?

The electric force is in the positive y-direction and has a magnitude given by
$F_{net} = qE_{net} = 3\times10^{-6}C\times7.64\times10^{4}\,\tfrac{N}{C} = 0.229N$.

4. How much work would it take to move the $q = 3\mu C$ charge from very far away and place it at rest at point P?

The work done is $W = -q\Delta V = -\left(3\times10^{-6}C\right)\times\left[-7.64\times10^{4}V - 0V\right] = 0.229J$.

5. If the $q = 3\mu C$ charge were released from rest at point P, its subsequent motion would most likely be
   a. to move along the y -axis toward positive infinity.
   b. to move along the y-axis towards negative infinity.
   c. to move along the y-axis towards the origin and stop at the origin.
   d. to move towards one of the two charges on the x-axis but which one would not be known.
   e. to oscillate about the x-axis.

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$N_A = 6.02\times10^{23}$

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

Electric Circuits

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$PE_{gravity} = mgy$$

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