Name____

Physics 111 Quiz #1, September 14, 2018

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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Suppose that you have two point charges in a line given by the following data; charge $q_1 = 5\mu C$ is located at $(x,y) = (-5,0)cm$ and charge $q_2 = 10\mu C$ is located at $(x,y) = (5,0)cm$.

1. What is the x-component of the net electric field at a point *P* in space with coordinates $(x,y) = (0,-10)cm$?

   The distance between each charge and point P is given by: $r = \sqrt{(0.05m)^2 + (-0.1m)^2} = 0.11m$.

   From the geometry of the system: $\cos\theta = \dfrac{0.05m}{0.11m} = 0.455$ and $\sin\theta = \dfrac{0.1m}{0.11m} = 0.909$.

   The x-component of the electric field:

$$E_{net,x} = E_1\cos\theta - E_2\cos\theta = \frac{kq_1}{r^2}\cos\theta - \frac{kq_2}{r^2}\cos\theta = \frac{k\cos\theta}{r^2}(q_1 - q_2)$$

$$E_{net,x} = \frac{9\times10^9 \frac{Nm^2}{C^2} \times 0.455}{(0.11m)^2}\left(5\times10^{-6}C - 10\times10^{-6}C\right) = -1.69\times10^6 \tfrac{N}{C}$$

2. What is the y-component of the net electric field at a point *P* in space with coordinates $(x,y) = (0,-10)cm$?

   The y-component of the electric field:

$$E_{net,y} = -E_1\sin\theta - E_2\sin\theta = -\frac{kq_1}{r^2}\sin\theta - \frac{kq_2}{r^2}\sin\theta = -\frac{k\cos\theta}{r^2}(q_1 + q_2)$$

$$E_{net,y} = -\frac{9\times10^9 \frac{Nm^2}{C^2} \times 0.909}{(0.11m)^2}\left(5\times10^{-6}C + 10\times10^{-6}C\right) = -1.01\times10^7 \tfrac{N}{C}$$

3. What is the net electric field at the point *P* in space with coordinates $(x,y) = (0,-10)cm$?

   The magnitude of the net electric field: $E_{net} = \sqrt{E_{net,x}^2 + E_{net,x}^2} = 1.02\times10^7 \tfrac{N}{C}$.

   The direction of the net electric field: $\phi = \tan^{-1}\left(\dfrac{E_{net,y}}{E_{net,x}}\right) = 80.5^o$ below the –x-axis.

4. Suppose that a point charge $q_3 = -3.6\mu C$ is placed at point P in space, what net electric force would q_3 feel due to q_1 and q_2?

The magnitude of the net electric force: $F_{net} = q_3 E_{net} = 3.6\times10^{-6} C \times 1.02\times10^{7} \frac{N}{C} = 36.7N$.

The direction of the net electric field: $\phi = \tan^{-1}\left(\frac{q_3 E_{net,y}}{q_3 E_{net,x}}\right) = 80.5^{o}$ above the +x-axis, opposite to the direction of the electric filed

5. Suppose that the point charges q_1 and q_2 were moved so that their new locations were $(x,y)=(-10,0)cm$ and $(x,y)=(10,0)cm$ respectively. In this new configuration the net electric force on q_3 would
   a. decrease because the distance between q_1 and q_2 and the point P increases.
   b. decrease because the distance between q_1 and q_2 and the point P decreases.
   c. remain the same.
   d. increase because the distance between q_1 and q_2 and the point P increases.
   e. increases because the distance between q_1 and q_2 and the point P decreases.

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

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

Geometry

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

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

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