Name_____

Physics 111 Quiz #2, September 24, 2021

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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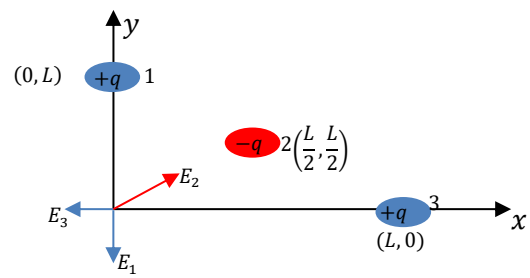
1. Suppose that you had the collection of point charges shown below with $|q| = 1.6 \times 10^{-19} C$. The charges lie in a line with the coordinates shown, where $L = 1\mu m$. What are the net horizontal and net vertical electric field components at the origin (0,0)?



$$E_{net,x} = E_{2x} - E_3 = \frac{kq}{\frac{L^2}{2}} \cos\theta - \frac{kq}{L^2} = \frac{kq}{L^2}[2\cos\theta - 1]$$

$$E_{net,x} = \frac{9 \times 10^9 \frac{Nm^2}{C^2} \times 1.6 \times 10^{-19} C}{(1 \times 10^{-6} m)^2}[2\cos 45 - 1] = 596.5 \frac{N}{C}$$

$$E_{net,y} = E_{2y} - E_1 = \frac{kq}{\frac{L^2}{2}} \sin\theta - \frac{kq}{L^2} = \frac{kq}{L^2}[2\sin\theta - 1]$$

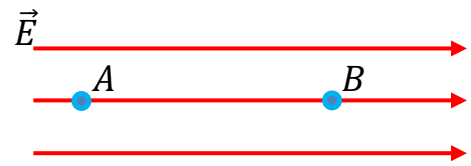
$$E_{net,y} = \frac{9 \times 10^9 \frac{Nm^2}{C^2} \times 1.6 \times 10^{-19} C}{(1 \times 10^{-6} m)^2}[2\sin 45 - 1] = 596.5 \frac{N}{C}$$

2. What is the magnitude and direction of the net electric field at the origin.

$$E_{net} = \sqrt{E_{net,x}^2 + E_{net,y}^2} = \sqrt{\left(596.5\frac{N}{C}\right)^2 + \left(596.5\frac{N}{C}\right)^2} = 843.6\frac{N}{C}$$

$\phi = \tan^{-1}\frac{E_{net,y}}{E_{net,x}} = \tan^{-1}\left(\frac{596.5\frac{N}{C}}{596.5\frac{N}{C}}\right) = 45^0$ or 45^0 above the positive x-axis.

3. Suppose that a uniform electric field exists as shown below and consider two points A and B and an unknown charge that is released from rest at a point located halfway between points A and B. How would you be able to tell what the sign of the unknown charge was? In other words, how would you know if the unknown charge was positive or negative and why? Explain your answer fully.



We release the charge and "watch" its motion through the field. If the charge moves toward point B, in the direction of the electric field, then the charge must be positive. If the charge moves toward point A, opposite to the direction of the electric field, then the charge must be negative.

4. Suppose for this question that the unknown charge from question 3 were an electron. If the electron were released from rest halfway between points A and B and was found to have acquired a speed of $1 \times 10^7 \frac{m}{s}$ after it was accelerated over a distance of $0.5m$, through what potential difference was the electron accelerated?

$$W = -q\Delta V = \Delta K = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2 \rightarrow \Delta V = -\frac{mv_f^2}{2q} = -\frac{9.11\times10^{-31}kg\times\left(1\times10^7\frac{m}{s}\right)^2}{2\times(-1.6\times10^{-19}C)} = 285V$$

5. What was the magnitude of the electric field that the electron was accelerated through?

$$E = \left|-\frac{\Delta V}{\Delta x}\right| = \frac{285V}{0.5m} = 570\frac{V}{m}$$

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

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

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

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

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

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

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

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

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

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

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

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

Light as a Wave

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

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

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

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

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

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

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

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

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

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

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

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

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

Light as a Particle & Relativity

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

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

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

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

$$p = \gamma mv$$

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

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

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

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

Geometry

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

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

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

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

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

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

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