Name_____

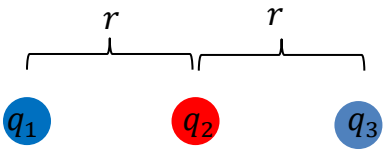
Physics 111 Quiz #1, January 15, 2021

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.

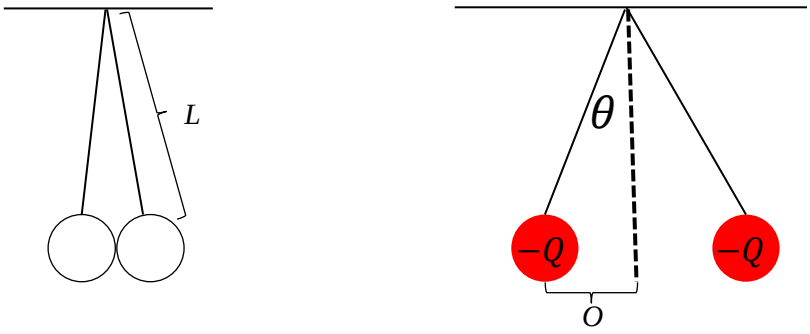
_____

1. Suppose that you have three point-charges in a line with $q_1 = +Q$, $q_2 = -2Q$, and $q_3 = +Q$ with the separation between successive charges r. What is the net electric force on point-charge q_3 due to point-charges $q_1$and $q_2$in terms of Q and r?



$$F_{net,3} = F_{3,1} - F_{3,2} = \frac{kQQ}{(2r)^2} - \frac{kQ(2Q)}{r^2} = -\frac{7}{4}\frac{kQ^2}{r^2}$$

Suppose instead that you have two initially uncharged point-spheres each with mass $m = 0.2kg$. The point-spheres are suspended from insulating strings of length $L = 1m$. The point-spheres are charged until they both acquire charge $-Q$. The point-spheres repel each other and come into equilibrium when they each make an angle of $\theta = 10^0$measured with resect to the vertical. As these are point-spheres assume the initial angle each makes with respect to the vertical is $0^0$and thus both are initially hanging vertically.



2. What is the equilibrium separation between the centers of the charged spheres when they come to rest?

$r = 2O$, where $\sin\theta = \frac{O}{L} \rightarrow O = L\sin\theta = 1m\sin 10 = 0.174m$. So, $r = 2 \times 0.174m = 0.347m$.

3. What is the magnitude of the tension force in the string?

$F_T \cos\theta - F_W = ma_y = 0 \rightarrow F_T \cos\theta = F_W = mg$

$$F_T = \frac{mg}{\cos\theta} = \frac{0.2kg \times 9.8\frac{m}{s^2}}{\cos 10} = 1.99N$$

4. How much total charge is on both of the spheres?

$F_T \sin\theta - F_e = ma_x = 0 \rightarrow F_T \sin\theta = F_e = \frac{kQ^2}{r^2}$

$$Q = \sqrt{\frac{F_T r^2 \sin\theta}{k}} = \sqrt{\frac{1.99N(0.347m)^2 \sin 10}{9 \times 10^9 \frac{Nm^2}{C^2}}} = 2.15 \times 10^{-6}C = 2.15\mu C$$

$Q_{total} = -2Q = -2 \times 2.15\mu C = -4.4\mu C$

5. Which of the following statements would be true if the ropes holding the charged spheres were suddenly shortened to $\frac{L}{2}$ from L?

   a. Both Q and F_e would decrease.

   b. Both Q and F_e would increase.

   c. Both r and F_e would decrease.

   d. Both r and F_e would increase.

   e. None of the above choices are correct.

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

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

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

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

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

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

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

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

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 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

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

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

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

Light as a Wave

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

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

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

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

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

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

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

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

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

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

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

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

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

Nuclear Physics

$$E_{binding} = \left(Zm_p + Nm_n - m_{rest}\right)c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

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

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