Name____

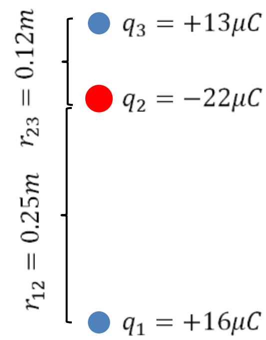
Physics 111 Quiz #1, September 17, 2021

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 charges and separations shown on the right. What is the net electric force on point-charge q_2 due to point-charges $q_1$and q_3?



$$F_{net,2} = +F_{2,3} - F_{2,1} = +k\frac{q_2 q_3}{r_{23}^2} - k\frac{q_2 q_1}{r_{21}^2}$$

$$F_{net,2} = 9 \times 10^9 \frac{Nm^2}{c^2} \times 22 \times 10^{-6}C \left[\frac{13 \times 10^{-6}C}{(0.12m)^2} - \frac{16 \times 10^{-6}C}{(0.25m)^2}\right]$$

$F_{net,2} = 128.1N$ vertically up.

2. If the mass of point-charge q_2 were $1\mu g$, what would be the magnitude and direction of the initial acceleration of q_2?

$F_{net,2} = m_2 a_2 \rightarrow a_2 = \frac{F_{net,2}}{m_2} = \frac{128.1N}{1\times10^{-6}g\times\frac{1kg}{1000g}} = 1.28 \times 10^{11}\frac{m}{s^2}$ vertically up toward q_3.

3. Suppose that you "scuff" your feet across a carpeted floor. In doing this, your body picks up electrons from the carpet. If you were to acquire an excess charge of $-45\mu C$ by walking across the carpet, how many electrons did you pick up from the carpet?

$$Q = ne \rightarrow n = \frac{Q}{e} = \frac{-45\times10^{-6}C}{-1e\times\frac{1.6\times10^{-19}C}{1e}} = 2.8 \times 10^{14}$$

4. Two point-charges of equal mass ($m = 1g$) are placed $0.2m$ apart. They are both charged so that each one has charge Q. In other words, $q_1 = q_2 = Q$. How much total charge was placed on both point-masses if the electric force between them was equal to the weight of either one near the Earth's surface?

$$F_W = F_e \rightarrow mg = k\frac{Q^2}{r^2} \rightarrow Q = \sqrt{\frac{mgr^2}{k}} = \sqrt{\frac{0.001kg\times9.8\frac{m}{s^2}\times(0.2m)^2}{9\times10^9\frac{Nm^2}{c^2}}} = 2.1 \times 10^{-7}C$$

$$Q_{total} = 2Q = 4.2 \times 10^{-7}C$$

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

Light as a Wave

$$c = fl = \frac{1}{\sqrt{e_o m_o}}$$

$$S(t) = \frac{energy}{time \times area} = ce_oE^2(t) = c\frac{B^2(t)}{m_o}$$

$$I = S_{avg} = \tfrac{1}{2}ce_oE_{\max}^2 = c\frac{B_{\max}^2}{2m_o}$$

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

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

$$v = \frac{1}{\sqrt{em}} = \frac{c}{n}$$

$$q_{inc} = q_{refl}$$

$$n_1\sin q_1 = n_2\sin q_2$$

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

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

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

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

$$HU = \frac{m_w - m_m}{m_w}$$

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

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

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

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