Name____

Physics 111 Quiz #2, September 25, 2020

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. The solar wind is a stream of charged particles (protons and electrons mostly) that come from the sun and interact with the magnetic field of the earth. As the particles travel down the magnetic field lines of the earth some interact with gasses in the atmosphere which produces the aurora while some make it to the ground? Suppose that a proton has a velocity of $2 \times 10^7 \frac{m}{s}$ vertically down towards the ground. If you wanted to bring the proton to rest over a distance of $25cm$, what magnitude and direction of an electric field would you need?

$$W = F\Delta y = qE\Delta y = \Delta K = \frac{1}{2}m_p v_{fp}^2 - \frac{1}{2}m_p v_{ip}^2 = -\frac{1}{2}m_p v_{ip}^2$$

$$E = -\frac{m_p v_{ip}^2}{2q\Delta y} = -\frac{1.67\times10^{-27}kg\left(2\times10^7\frac{m}{s}\right)^2}{2\times1.6\times10^{-19}C\times(0m-0.25m)} = 8.35 \times 10^6 \frac{V}{m}$$ vertically upwards.

2. The electric field that you would need to bring the proton to rest would create a potential difference across the region of space over which the field acts. What potential difference would be created?

$$E = -\frac{\Delta V}{\Delta y} \to \Delta V = -E\Delta y = -8.35 \times 10^6 \frac{V}{m} \times (0m - 0.25m) = 2.09 \times 10^6 V$$

Or

$$W = -q\Delta V = \Delta K \to \Delta V = -\frac{\Delta K}{q} = \frac{\frac{1}{2}m_p v_{ip}^2}{q} = \frac{1.67 \times 10^{-27}kg\left(2 \times 10^7\frac{m}{s}\right)^2}{2 \times 1.6 \times 10^{-19}C} = 2.09 \times 10^6 V$$

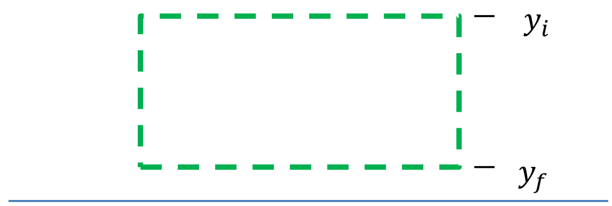
3. Suppose that the potential difference was created over the region of space shown below by the dashed box. With respect to the ground, let $y_i$be the location top of the potential difference and y be the location of the bottom of the potential difference. Compared to y_i, which of the following is true?

   a. The location of y_f is at a lower electric potential than y_i.

   b. The location of $y_f$is at the same electric potential as y_i.

   c. The location of y_f is at a higher electric potential than y_i.

   d. There is no way to tell what electric potential y_f is at compared to y_i form the information given.



4. Imagine instead of the situations above you had two, point charges each with magnitude $q = 2\mu C$ oriented on the x-axis separated by a horizontal distance of $s = 1.2cm$. What is the electric potential at the midpoint between the two charges?

$$V_p = V_{q1} + V_{q2} = \frac{kq_1}{r_{1s}} + \frac{kq_2}{r_{2s}} = \frac{kq}{s/2} + \frac{kq}{s/2} = \frac{4kq}{s}$$

$$V_p = \frac{4 \times 9 \times 10^9 \frac{Nm^2}{C^2} \times 2 \times 10^{-6} C}{0.012m} = 6 \times 10^6 V$$

5. How much work (in eV) would be required to bring a third charge ($q' = -1\mu C$) from very far away and place it at the midpoint between the two charges?

$$W = -q\Delta V = -q_3\left[V_{fp} - V_{i\infty}\right] = -(-1 \times 10^{-6} C)[6 \times 10^6 V - 0V] = 6J$$

$$W = 6J \times \frac{1eV}{1.6 \times 10^{-19} J} = 3.8 \times 10^{19} eV$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Light as a Particle & Relativity

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

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

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

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

$$p = \gamma mv$$

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

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

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

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

Nuclear Physics

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

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

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

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

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

Geometry

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

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

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

Misc. Physics 110 Formulae

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

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

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

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

$$PE_{gravity} = mgy$$

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

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

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

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

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

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