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HW#1

1) I understand plasmas to be ionized states of matter, whether that be solid, liquid, or gas. However, I have some issue with describing plasmas as another state of matter. Personally, I believe ionization percentage to be a property of the material. Even if it is another state of matter, I do not believe it should be given the same classification level as solid, liquid, & gas.

Now actually about plasmas; the most universally abundant material we understand is plasma. Plasma is a cluster of particles where the atoms have been ionized & the electrons seperate. This gives rise to a locally charged, but globally quasineutral state. This bulk material is now subject to electromagnetic forces as it can be approximated as two fluids occupying the same space w/ equal & opposite charges.

There are abundant usages of plasma on earth, which include, but are not limited to; keeping the earth's magnetosphere w/ a plasma core, exotic/high energy chemistry, glue that can bond metals together, transistor fabrication, lightning, aurora borealis/australis, welding, neon signs, certain lights, and the list goes on. Things are different for the universe as plasmas are found as stars, nebulas, supernovae, and quasars are what come to mind.

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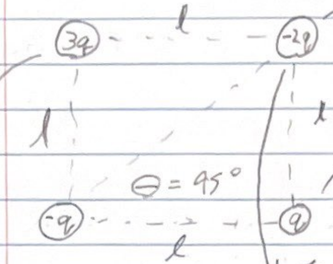
HW#1-cont'd

2)



x comp

$$E_x = \frac{kq}{l^2} + \frac{-2kq}{2l^2}\cos\theta = \frac{kq}{l^2} - \frac{kq}{l^2}\cdot\frac{\sqrt{2}}{2}$$

$$\Rightarrow \frac{kq}{l^2}\left(1 - \frac{\sqrt{2}}{2}\right) = E_x$$

y comp

$$E_y = \frac{3kq}{l^2} - \frac{2kq}{2l^2}\sin\theta = \frac{3kq}{l^2} - \frac{kq}{l^2}\cdot\frac{\sqrt{2}}{2} = \frac{kq}{l^2}\left(3 - \frac{\sqrt{2}}{2}\right) = E_y$$

$$\vec{E} = \left(\frac{kq}{l^2}\left[1 - \frac{\sqrt{2}}{2}\right], \frac{kq}{l^2}\left[3 - \frac{\sqrt{2}}{2}\right]\right) = \frac{kq}{l^2}\left(1 - \frac{\sqrt{2}}{2}, 3 - \frac{\sqrt{2}}{2}\right)$$

$$|\vec{E}| = \frac{kq}{l^2}\sqrt{\left(1 - \frac{\sqrt{2}}{2}\right)^2 + \left(3 - \frac{\sqrt{2}}{2}\right)^2}$$

$$\left.\begin{aligned}\left(1 - \frac{\sqrt{2}}{2}\right)\left(1 - \frac{\sqrt{2}}{2}\right) &= 1 - \sqrt{2} + \frac{2}{4} = \frac{3}{2} - \sqrt{2} \\ \left(3 - \frac{\sqrt{2}}{2}\right)\left(3 - \frac{\sqrt{2}}{2}\right) &= 9 - 3\sqrt{2} + \frac{2}{4} = \frac{19}{2} - 3\sqrt{2}\end{aligned}\right\} + = 11 - 4\sqrt{2}$$

$\therefore |\vec{E}| = \frac{kq}{l^2}\sqrt{11 - 4\sqrt{2}}$ & $F = q_i E$, so

$$\boxed{\begin{aligned}|\vec{F}| &= \frac{kq^2}{l^2}\sqrt{11 - 4\sqrt{2}} \\ |\vec{F}| &= 8.321\ N\end{aligned}}$$

$$= \frac{\overset{[Nm^2/C^2]}{9e^9} \times \overset{[C]^2}{(1.0e^{-6})^2}\sqrt{11 - 4\sqrt{2}}}{\underset{[m]^2}{[.05]^2}}$$

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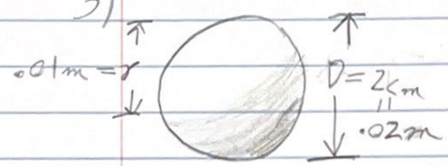
HW#1 - cont

3)



w/ $\rho = 2.4\ C/m^3$ $\qquad \epsilon_0 = 8.85e^{-12}\ \frac{C^2}{Nm^2}$

a) $\vec{E}_a = \frac{\rho r_a \hat{r}}{3\epsilon_0} = \frac{\overset{[C/m^3]}{2.4} \times \overset{[m]}{.005}\,\hat{r}}{3\epsilon_0} = \boxed{4.5198e8\,\hat{r}\ N/C \ @\ r = .005\ m}$

b) $\vec{E}_b = \frac{\rho r_b \hat{r}}{3\epsilon_0} = \frac{2.4 \times .01\,\hat{r}}{3\epsilon_0} = \boxed{9.0395e8\,\hat{r}\ N/C \ @\ r = .01\ m}$

c) $\vec{E}_c = \frac{1}{4\pi\epsilon_0} \cdot \frac{V\rho}{r_c^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{\frac{4}{3}\pi r_b^3}{r_c^2} = \frac{\rho}{3\epsilon_0} \frac{r_b^3 \hat{r}}{r_c^2} = \boxed{3.6158e7\,\hat{r}\ N/C @ r = .05m}$

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HW#1 - cont

4a) it will move in a circular path until the B field is gone.

b) gyro-frequency $\omega = \frac{qB}{m}$

where $q = 1.602e^{-19} C$
$B = 1\ T$
$m = 9.11e{-21}\ kg$

$\boxed{\therefore \omega = 1.7585e^{11}\ kg}$

c) know $F = qvB$, but also $F = ma$, However, a is circular, so $F = \frac{mv^2}{R}$, so...

$qvB = \frac{mv^2}{R} \Rightarrow R = \frac{mv}{qB}$, but need to find v, so use

$E = \frac{1}{2}mv^2 = k_B T \Rightarrow v^2 = \frac{2k_B T}{m} \Rightarrow v = \sqrt{\frac{2k_B T}{m}}$

$\therefore R = \frac{m}{qB}\sqrt{\frac{2k_B T}{m}} = \frac{1}{qB}\sqrt{2mk_B T}$

where $k_B = 1.38e{-23}\ \frac{m^2\,kg}{s^2 K}$
$T = 100{,}000\ K$

$m = 9.109e^{-31}\ kg$
$B = 1\ T$
$q = 1.602e{-19} C$

$\Rightarrow \boxed{R = 9.29775e{-6}\ m}$

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HW#1 - cont.

5) $F = q(E + v \times B)$ & $\nabla \times B = \mu_0 J + \mu_0 \epsilon_0 \frac{\partial E}{\partial t}$

However, $E = 0$, so $F = qv \times B$ & $\frac{\partial E}{\partial t} = 0$

$\Rightarrow$ $F = qv \times B$ & $\nabla \times B = \mu J$

using the relation

$\Rightarrow (B \cdot \nabla) B = \nabla\left(\frac{1}{2} B^2\right) - B \times (\nabla \times B)$, but $\nabla \times B = \mu J$, so

$\Rightarrow \frac{1}{2} \nabla B^2 = B(\underbrace{\nabla \cdot B}_{0,\ \text{maxwells laws}}) + B \times (\nabla \times B)$; $\frac{1}{2} \nabla B^2 = B \times \mu J$

$\Rightarrow J \times B = \frac{1}{2\mu_0} \nabla B^2 = \nabla\left(\frac{B^2}{2\mu_0}\right)$ where $J \times B$ is Lorentz Force/unit V, so

$\Rightarrow F/V = \nabla\left(\frac{B^2}{2\mu_0}\right)$ $\Rightarrow \int F/V \, dx = \int \nabla \frac{B^2}{2\mu_0} \, dx$

take a spatial integral & assume B is only function of x, integral of V is area, so...

$\Rightarrow F/a = \frac{B^2}{2\mu_0}$ $\rightarrow$ w/ F/a being pressure (P), we get...

$$\boxed{P = \frac{B^2}{2\mu_0} \quad \text{no need for } || \text{ as } B \cdot B \text{ is always positive}}$$