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**General Physics-II, Final-2**
PHYS1000AA, AB, AC: 106-2
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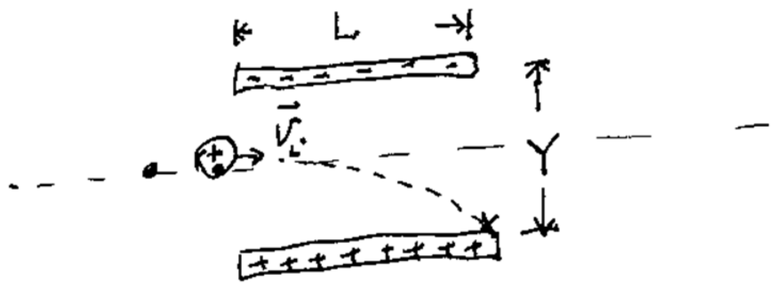
**Final Exam.2 –Solution**

1.




$$F_e = QE = ma \rightarrow \text{So the } a_y = \frac{-QE}{m}$$

$$V_x = V_i = \text{constant}$$

$$v_y = a_y t = -\frac{eE}{m} t$$

To hit the lower end, it has to be a negative Charge, and travels $\frac{1}{2}$ Y distance in the $-\hat{y}$ direction

$$\therefore \frac{1}{2} Y = \frac{1}{2} a_y t^2 = -\frac{1}{2} \frac{QE}{m} t^2$$

to get $t$, it is the distance and time in the $\hat{x}$-direction

$$x = V_i t, \quad t = \frac{L}{V_i}$$

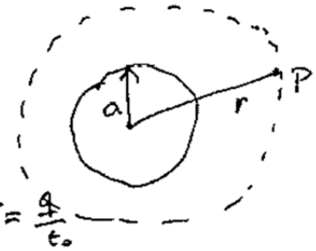
$$\therefore \frac{1}{2} Y = -\frac{1}{2} \frac{QE}{m} \left(\frac{L}{V_i}\right)^2$$

$$\therefore E = Y \frac{V_i^2}{L^2} \frac{m}{Q}$$

(2) A Spherically Symmetric Charge distribution

(2)-1 : A point outside the sphere

Pick a Gaussian surface bigger than the surface

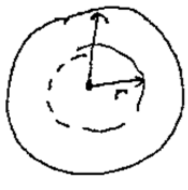



$$\Phi_E = \oint E \cdot dA = E \oint dA = E \cdot 4\pi r^2 = \frac{q}{\epsilon_0}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = k_e \frac{q}{r^2} \quad (r > a)$$

(2)-2 . A point ~~read~~ inside the sphere.

Pick a Gaussian surface as shown



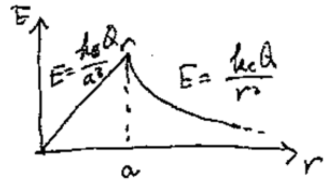

$$q_{in} = \rho V' = \rho \cdot \frac{4}{3}\pi r^3$$

$$\Phi_E = \oint E dA = E \oint dA = E(4\pi r^2) = \frac{q_{in}}{\epsilon_0}$$

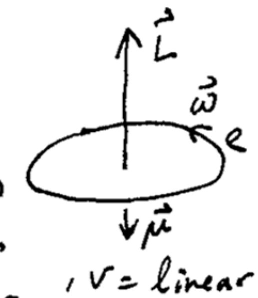
$$E = \frac{q_{in}}{4\pi\epsilon_0 r^2} = \frac{\rho(\frac{4}{3}\pi r^3)}{4\pi\epsilon_0 r^2} = \frac{\rho}{3\epsilon_0} r$$

$$\rho = Q \big/ \tfrac{4}{3}\pi a^3$$

$$\therefore E = \frac{Qr}{4\pi\epsilon_0 a^3} = k_e \frac{Q}{a^3} r, \quad (r < a)$$




3 Consider an electron moving around the atom




$$I = \frac{Q}{T} = \frac{Q\omega}{2\pi} = \frac{Qv}{2\pi r}, \quad v = \text{linear velocity}$$

$$\mu = \cancel{\quad} = IA = \frac{Qv}{2\pi r} \cdot \pi r^2 = \frac{1}{2} Q v r$$

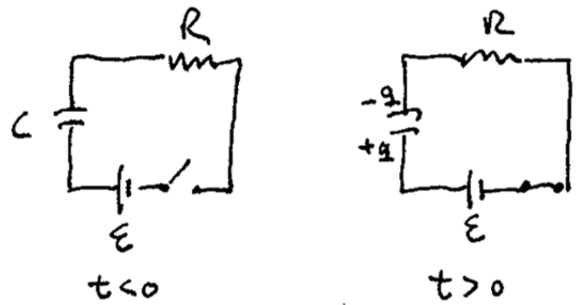
$$Q r, \quad \mu = \frac{1}{2m} m v r Q \qquad \text{But } L = mvr$$

$$= \left(\frac{Q}{2m}\right) L = \left(\frac{Q}{2m}\right) L$$ — This is the classical magnetic ~~momentum~~ moment

4. Let d is the diameter of the aperture, then $d\sin\theta = \lambda$ is the first minimum of the central bright diffraction pattern. $\theta$=1°, $\sin\theta \cong \theta$ = 1° = $\pi/180$

So, $d = \dfrac{420\times10^{-9}m}{\sin(\frac{\pi}{180})} = \dfrac{420\times10^{-9}}{3.14/180} = 24\mu m$

5




Use Kirchhoff's law

$$\mathcal{E} - \frac{q}{C} - IR = 0$$

① at t=0 . Capacitor is not charged $I_0 = \frac{\mathcal{E}}{R}$

When the capacitor is completely charged, $I = 0$

$Q = CV$

$$\mathcal{E} - \frac{q}{C} - IR = 0$$

$$I = \frac{\mathcal{E}}{R} - \frac{q}{RC}$$

$$\boxed{\frac{dq(t)}{dt} + \frac{1}{RC}q(t) - \frac{\mathcal{E}}{R} = 0}$$ — Ans

This is the first order differential equation

a possible Solution is

$$q(t) = C\mathcal{E}(1 - e^{-t/RC})$$

$$= Q(1 - e^{-\frac{t}{RC}})$$

6. displacement current:

Maxwell introduced an extra term in Ampere's law to take care of the current induced ~~in~~ due to a time varying electric field.

Ampere's law $\oint B \cdot ds = \mu_0 I$

Maxwell's ~~law~~ equation $\oint B \cdot ds = \mu_0 (I + I_d)$

$I_d$ = displacement current $\equiv \epsilon_0 \dfrac{d\Phi_E}{dt}$