Revision Booster WORKSHOP for NEET & JEE Main

Electrostatics & Gravitation

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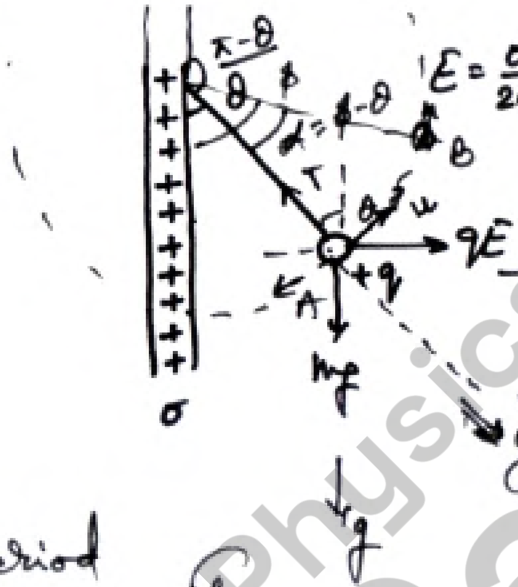
Questions Based on

Equilibrium of a Bob Hanging From a Charged Sheet



$$E = \frac{\sigma}{2\epsilon_0} \Big/ \frac{\sigma}{\epsilon_0}$$

$$T\sin\theta = qE$$

$$T\cos\theta = mg$$

$$\theta = \tan^{-1}\frac{qE}{mg}$$

$$T = \sqrt{(qE)^2 + (mg)^2}$$

$$qE \rightarrow a = qE/m$$

$$g_{eff} = \sqrt{g^2 + a^2}$$

Osc period

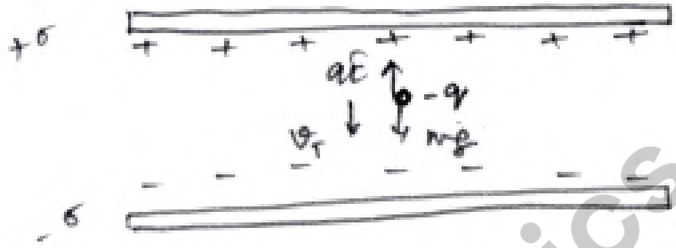
$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

W/E theorem from A to B

Questions Based on

Oil Drop in Millikan Experiment

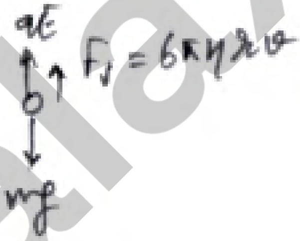
for eqm of drop



$q\frac{\sigma}{\epsilon_0} = mg$

$q = ne$

If drop is moving at T. speed

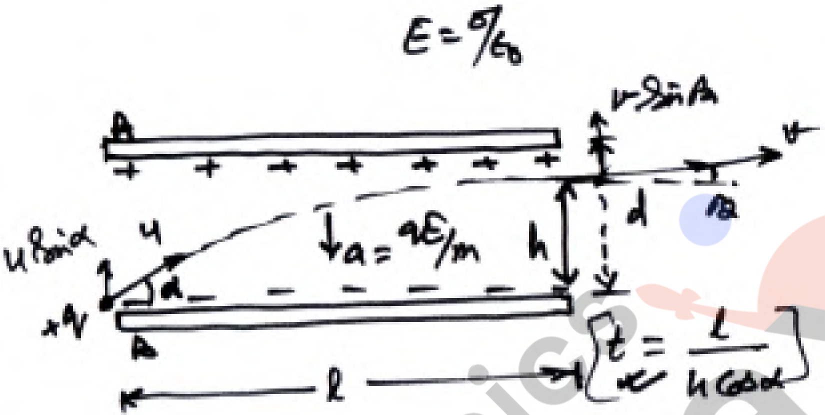


at T. speed

$[qE + 6\pi\eta r v = \frac{4}{3}\pi r^3 \rho g]$

Questions Based on

Projectile Inside a capacitor



$$u\cos\alpha = v\cos\beta$$

$$v\sin\beta = u\sin\alpha - gt \quad \rightarrow a = \frac{q\sigma}{m\varepsilon_0}$$

$$h = u\sin\alpha\, t - \frac{1}{2}at^2$$

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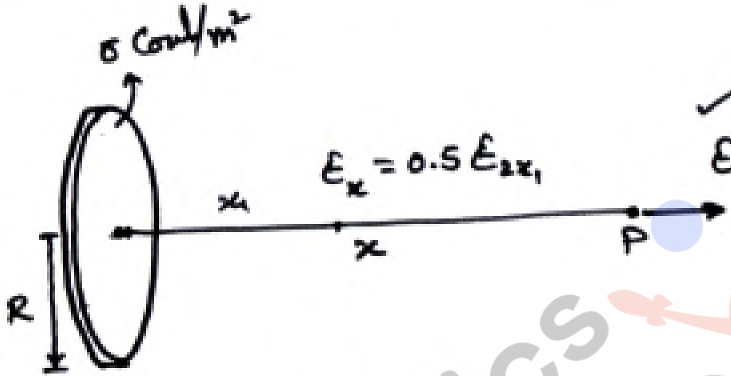
QUESTIONS BASED ON

ELECTRIC FIELD VARIATION ALONG AXIS OF A DISC



$$E = \frac{\sigma}{2\epsilon_0}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$$

at $x \to 0 \longrightarrow E = \frac{\sigma}{2\epsilon_0}$

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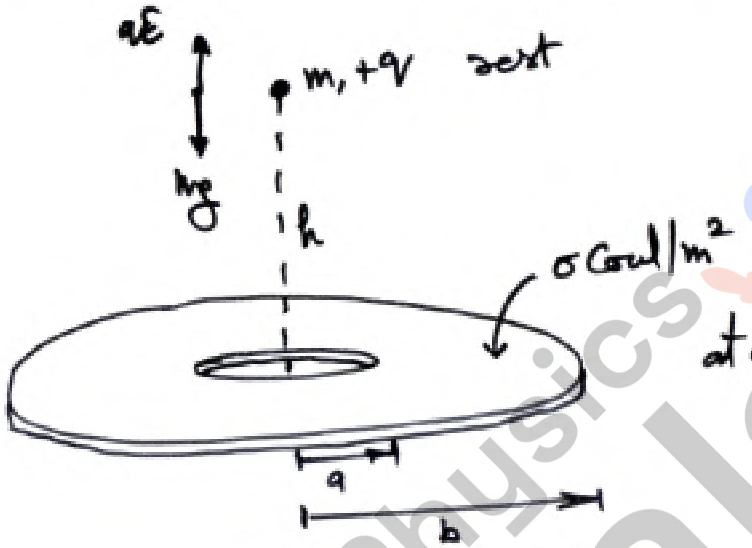
Questions Based on

Particle in Equilibrium Over an Annular Disc



$$E = E_b - E_a$$

$$E = \frac{\sigma}{2\epsilon_0}\left[\left(1 - \frac{h}{\sqrt{h^2+b^2}}\right) - \left(1 - \frac{h}{\sqrt{h^2+a^2}}\right)\right]$$

at eq^m $\quad mg = qE$

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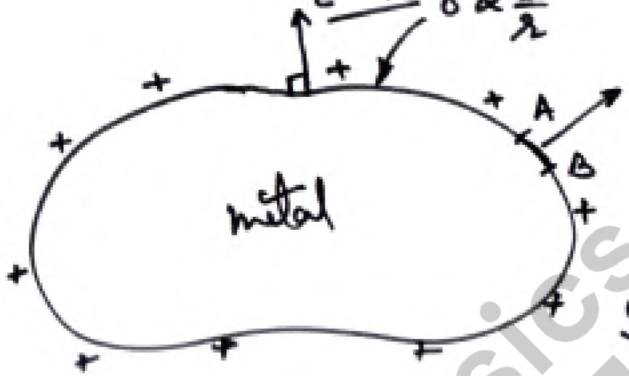
Questions Based on

Electric Field Just Outside a Charged Conductor

$E = \sigma/\epsilon_0$ (v. close to surface)

$\sigma \propto \frac{1}{r}$



$P_e \rightarrow$ electric pressure

$$P_e = \frac{\sigma^2}{2\epsilon_0}$$

Just outside AB, field energy density (J/m^3)

$$u_e = \frac{\sigma^2}{2\epsilon_0} = \frac{1}{2}\epsilon_0 E^2$$

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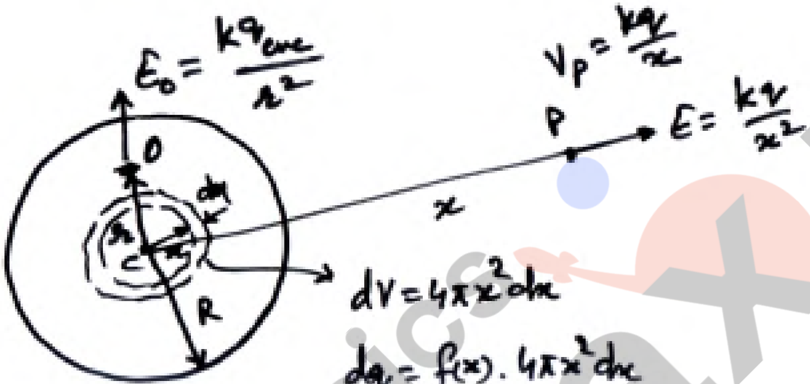
Questions Based on

Electric Field & Potential Due to Spherical Charge Distribution



$$dq = f(x) \cdot 4\pi x^2 dx$$

$$\rho_{(r)} = f(r)$$

$$q = \int_0^R$$

$$q_{encl} = \int_0^r \quad = \text{—}$$

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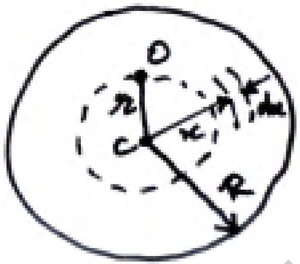
Questions Based on

Electric Potential Inside a Spherical Charge Distributions

$$V_0 = \left|\int_{\infty}^{R} (E_{out} \cdot dx)\right| + \left|\int_{R}^{r} |E_{in} \cdot dx|\right|$$



OR

$$V_0 = \left[\frac{K q_{encl}}{r} + \int_{r}^{R} \frac{(f(x) \cdot 4\pi x^2 dx) K}{x}\right]$$

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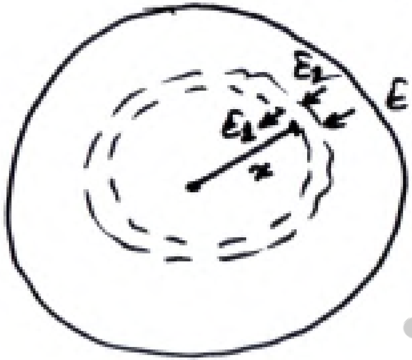
QUESTIONS BASED ON

CALCULATION OF CHARGE DISTRIBUTION

$V = f(x) = ax^2 + b$ find $\rho(x) = ?$



$E = -\frac{dV}{dx} = -2ax$

$E_2 = -2ax$

$E_1 = -2a(x+dx)$

Gauss's law on elemental shell, we get

$$E_2(4\pi(x+dx)^2) - E_1(4\pi x^2) = \frac{dq}{\epsilon_0} = \frac{\rho(x) \cdot 4\pi x^2 dx}{\epsilon_0}$$

$\rho(x) =$ ______

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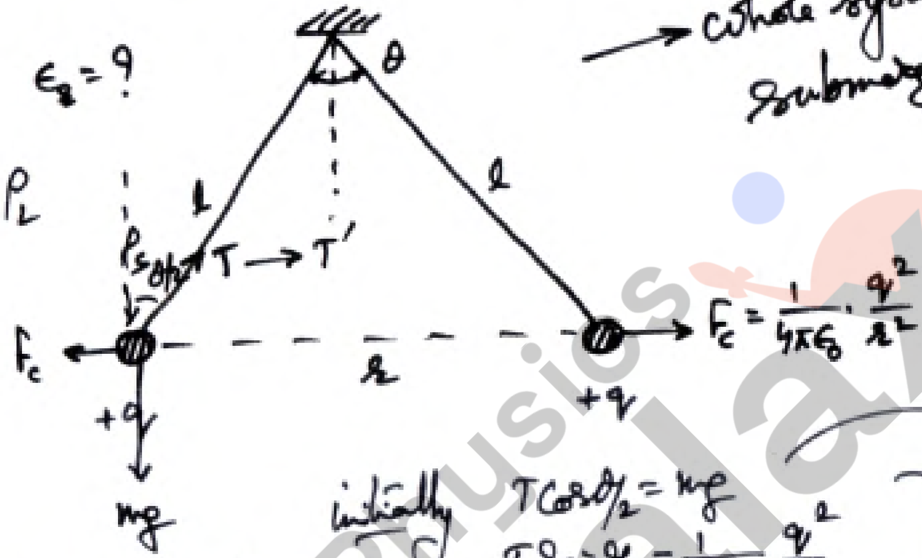
QUESTIONS BASED ON

PENDULUMS SUBMERGING IN A LIQUID



→ Whole system is submerged in a liquid

for eq^n of both

initially
$$T\cos\theta/2 = mg$$
$$T\sin\theta/2 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$$

finally
$$T'\cos\theta/2 = mg\left(1-\frac{\rho_L}{\rho_s}\right)$$
$$T'\sin\theta/2 = \frac{1}{4\pi\epsilon_0\epsilon_r}\cdot\frac{q^2}{r^2}$$

$$\tan\theta/2 = \tan\theta/2$$

→ - - - - -

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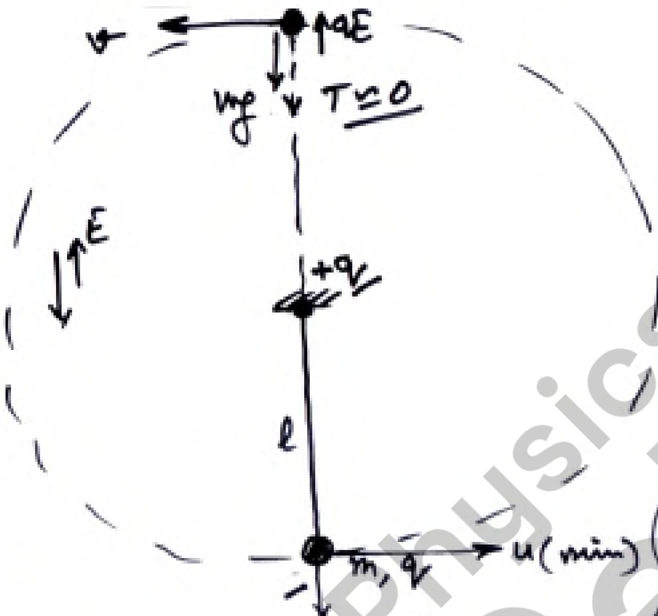
Questions Based on

Vertical Circular Motion With Charges in EF



$F_c = \frac{kq^2}{l^2}$

$g_{eff} = g \pm \frac{qE}{m}$

In presence of EF $u_{min} = \sqrt{5 g_{eff} l}$.

In presence of +q at suspension pt

at topmost point speed of bob

$v = \sqrt{u^2 - 4gl}$.

At topmost pt, we use

for u_{min} —

$mg - qE = \frac{mv^2}{l}$

$u_{min} =$ ———— Ans

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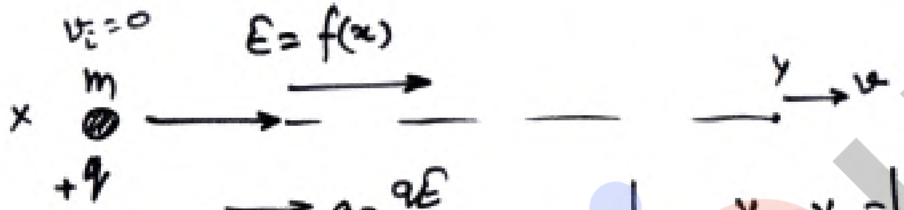
QUESTIONS BASED ON

A CHARGE MOVING IN NON-UNIFORM EF



$\rightarrow a = \frac{qE}{m}$

$v\frac{dv}{dx} = \frac{qE_x}{m}$

$\int_0^v v\,dv = \int_0^x \frac{qE_x}{m}\,dx$

$V_x - V_y = \left|\int_0^x E_x\,dx\right|$

W/E theorem $\Rightarrow q(V_x - V_y) = \frac{1}{2}mv^2$

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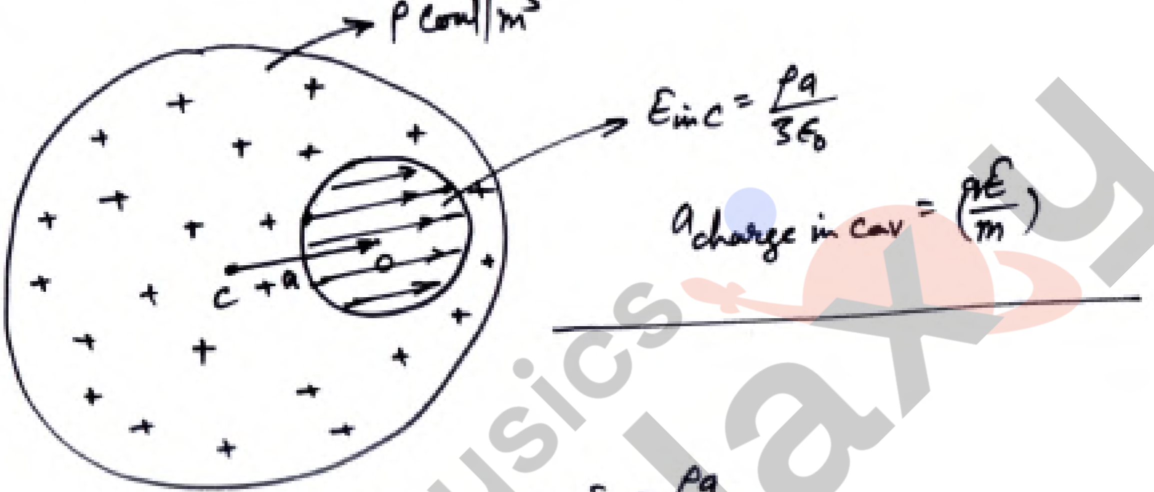
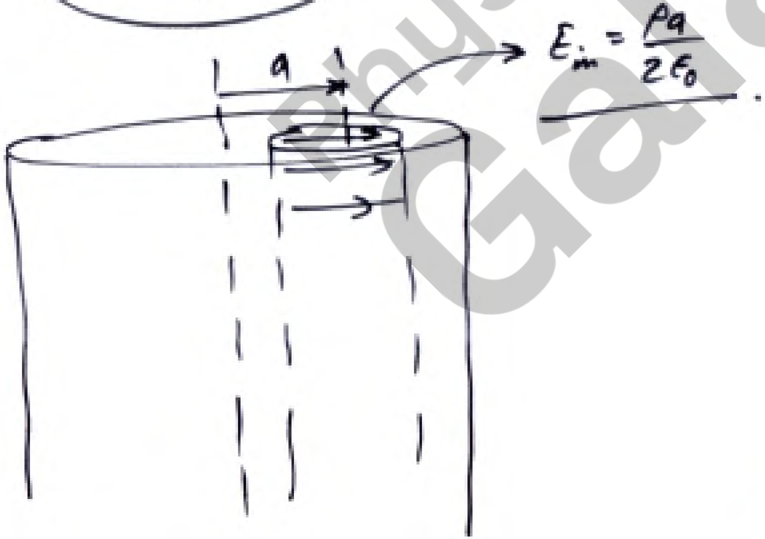
QUESTIONS BASED ON

MOTION OF A CHARGE INSIDE CAVITY





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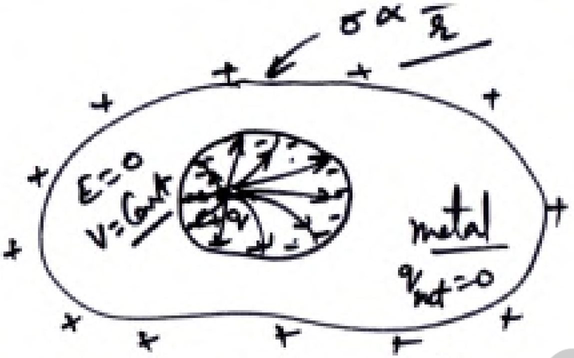
QUESTIONS BASED ON

INDUCED CHARGES INSIDE METAL CAVITIES



flux from a pt charge

$$\phi = \frac{q}{\epsilon_0}$$

amt of induced surface charges on cavity inner surfaces $q_{in} = -q$

Surface of cavity close to pt charge has higher value of σ_i (-ve)

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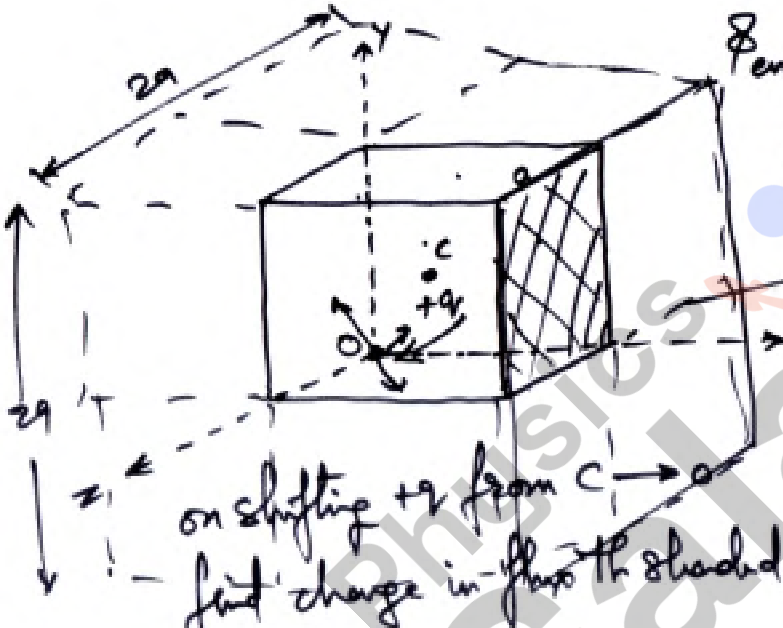
QUESTIONS BASED ON

ELECTRIC FLUX FROM A CUBICAL SURFACE



on shifting +q from C → O
find change in flux through shaded face

$\phi_{emerge} = \frac{q}{\epsilon_0}$

$\phi_{each\,face} = \frac{q}{6\epsilon_0}$ ✓

$q_{shaded} = \frac{q}{24\epsilon_0}$

$q_{cube} = \frac{q}{8\epsilon_0}$

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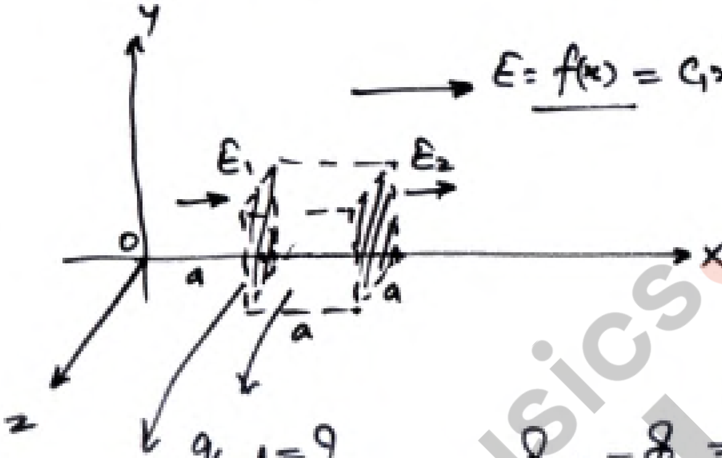
Questions Based on

Charge Enclosed in a Cube in Varying Electric Field

$$E = f(x) = C_1x^2 + C_2$$



$$\phi_{in} = (C_1a^2 + C_2)\cdot a^2$$

$$\phi_{out} = (C_1(4a^2) + C_2)\, a^2$$

area $= a^2$

$q_{encl} = ?$

$$\phi_{out} - \phi_{in} = \frac{q_{encl}}{\epsilon_0}$$

$q_{encl} =$ —— ✓

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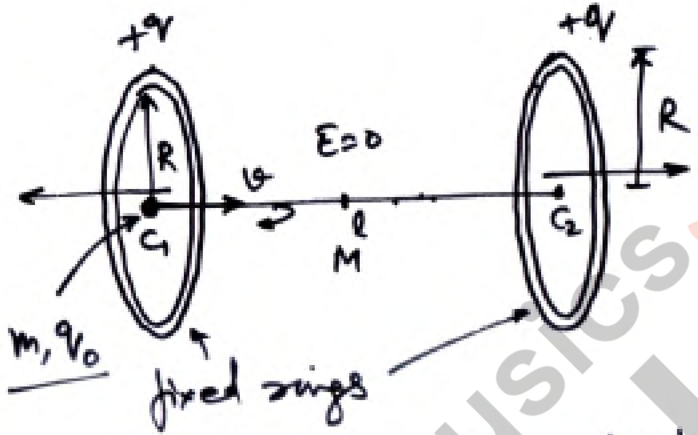
QUESTIONS BASED ON

THROWING OF A PARTICALE BETWEEN RING CENTERS



if KE reqd to cross null pt is $K = \frac{1}{2}mv_{min}^2$

$$\Rightarrow \quad K \geq q(V_M - V_{C_1})$$

$$\frac{1}{2}mv_{min}^2 = q\left[2\frac{kq}{\sqrt{R^2+(l/2)^2}} - \left(\frac{kq}{R} + \frac{kq}{\sqrt{l^2+R^2}}\right)\right]$$

$$v_{min} = \text{——} \quad \text{Ans}$$

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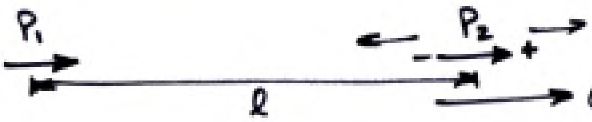
Questions Based on
Force Between Two Dipoles

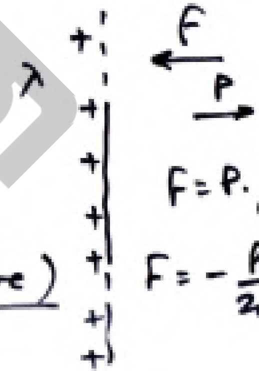
force on a dipole $F = +\vec{P}\frac{d\vec{E}}{dx}$



$E_x = \frac{2kP_1}{l^3}$

force on P_2 is given as

$$F = P_2\frac{2kP_1}{l^4}\times 3 = -\frac{6kP_1P_2}{l^4} \quad \text{(attractive)}$$



$$F = P\cdot\frac{d}{dx}\left(\frac{\lambda}{2\pi\epsilon_0 x}\right)$$

$$F = -\frac{P\lambda}{2\pi\epsilon_0 x^2}$$

$\vec{F} = -\frac{dU}{dx}\hat{i}$ and $U = -\vec{P}\cdot\vec{E}$

$$\vec{F} = \left(\vec{P}\cdot\frac{d\vec{E}}{dx}\right)\hat{i}$$

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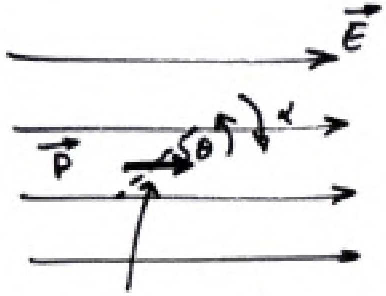
QUESTIONS BASED ON

OSCILLATION OF A DIPOLE IN EXTERNAL EF



if dipole is slightly rotated, restoring torque on dipole

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$\tau_R = pE\sin\theta$$

for small θ $\quad \tau_R = pE\theta$

$$I\alpha = pE\theta$$

$$\alpha = -\frac{pE}{I}\theta$$

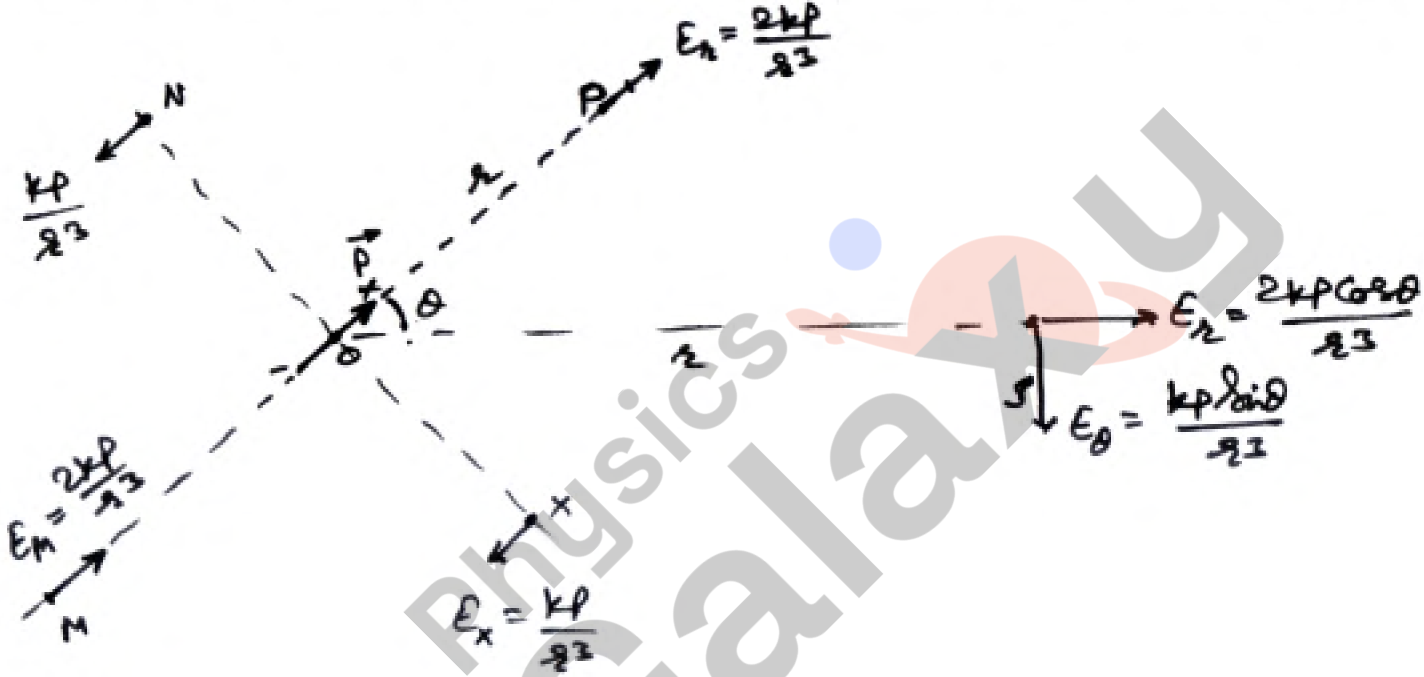
Comp with $\alpha = -\omega^2\theta$

$$\omega = \sqrt{\frac{pE}{I}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{pE}}$$

Questions Based on

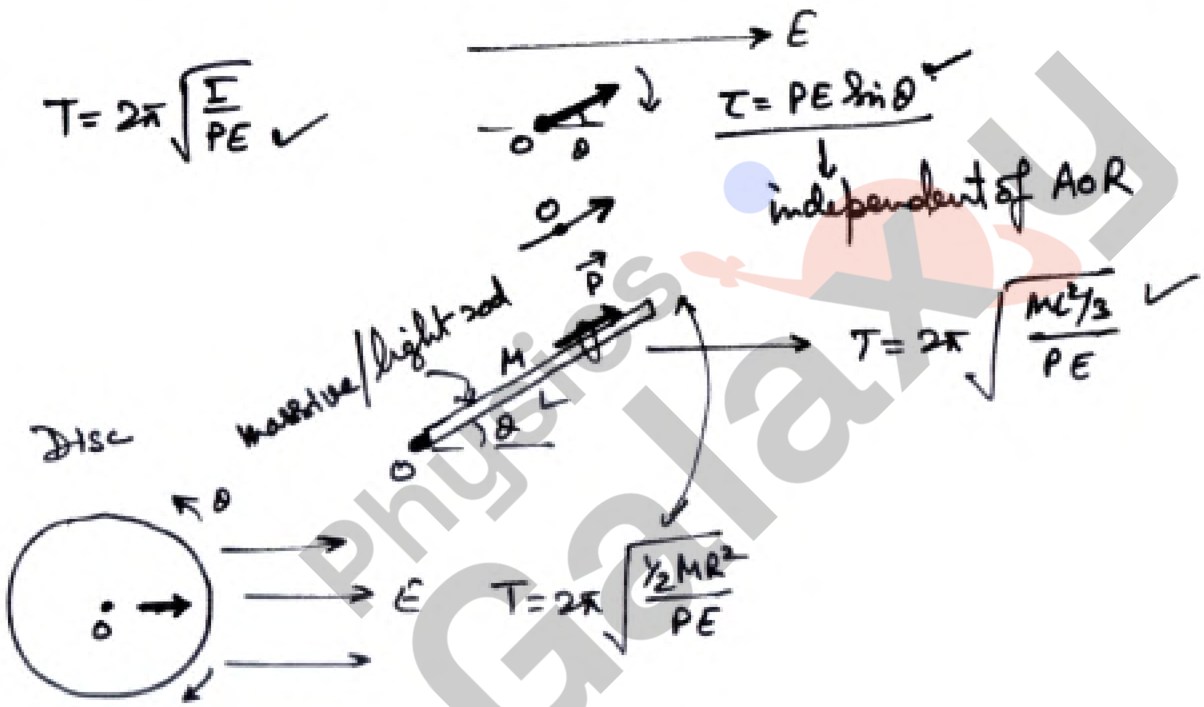
Directions of Radial & Transverse Field Due to a Dipole



Questions Based on

Oscillation of Bodies in Electric Field With a Dipole

$$T = 2\pi\sqrt{\frac{I}{PE}}$$



Questions Based on

Potential Energy of a Point Charge & Dipole

due to the Interaction bet^n q & P

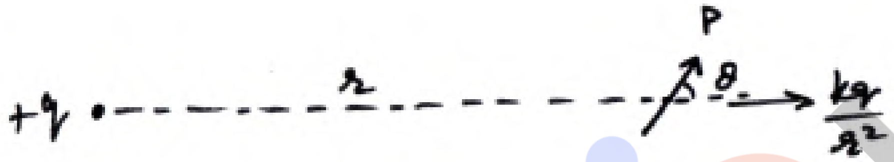
$E = \frac{kq}{r^2}$

$\text{If } E_q \rightarrow U = qV = q\left(\frac{kp}{r^2}\right) = \frac{kqp}{r^2}$ ✓

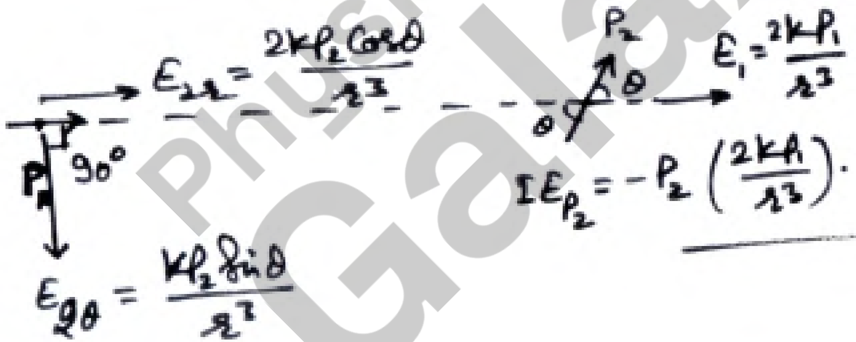
$\text{If } E_p \rightarrow U = -pE\cos\theta = -p\left(\frac{kq}{r^2}\right)\cos 180^\circ = \frac{kqp}{r^2}$ ✓

QUESTIONS BASED ON

POTENTIAL ENERGY OF TWO DIPOLES



$$U_p = -PE\cos\theta = -P\left(\frac{kq}{r^2}\right)\cos\theta$$



$$U_{P_2} = -P_2\left(\frac{2kP_1}{r^3}\right)\cdot\cos\theta$$

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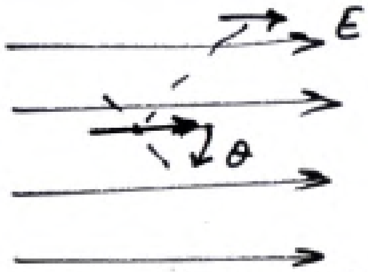
QUESTIONS BASED ON

WORK DONE IN MOVING A DIPOLE



initial PE → U_i

final PE → U_f

$W_{ext} = U_f - U_i$

$W_{sys} = U_i - U_f$

$U_i = -PE$

$U_f = -PE\cos\theta$

$W_{ext} = PE(1-\cos\theta)$

$W_{field} = PE(\cos\theta - 1)$

NOTE: if dipole orientation is not changing in motion

$W = 0$.

if I is MI of dipole, we can use

$W_{ext} = \frac{1}{2} I\omega^2 \rightarrow \omega = \_\_\_\_$ ✓

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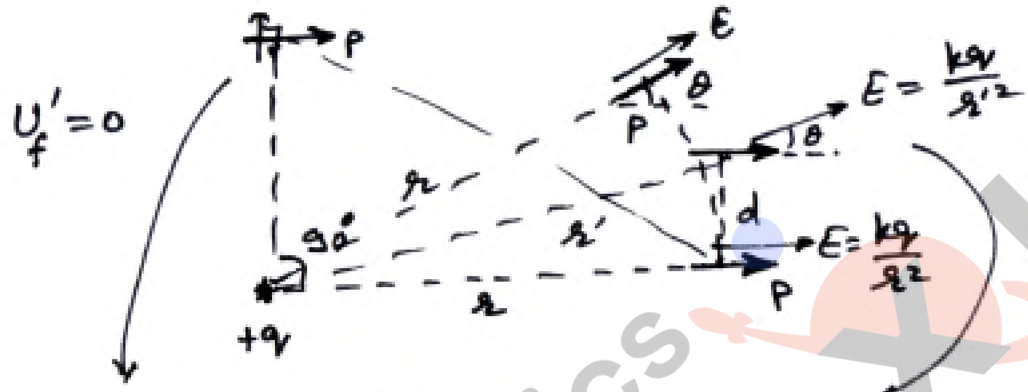
QUESTIONS BASED ON

WORK IN DISPLACING A DIPOLE IN SURROUNDING OF A CHARGE



$U = -PE\cos\theta$

$U_i = -P\left(\frac{kq}{r^2}\right) = U_f$

$W_{ext} = 0$

$W = 0 - \left(-\frac{kpq}{r^2}\right) = \text{—}$

$U_f = -P\left(\frac{kq}{r'^2}\right)\cos\theta \Rightarrow W_{ext} = U_f - U_i = \text{—}$

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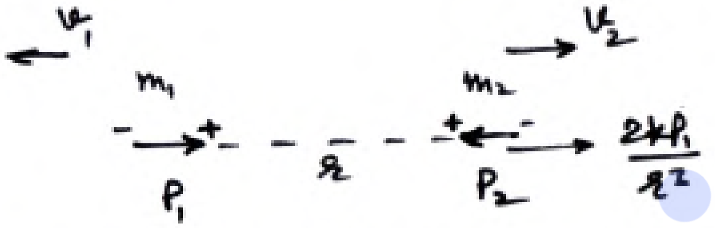
QUESTIONS BASED ON

KINETIC ENERGY IN REPELLING DIPOLES



find KE of P_1 and P_2 when sep increased to $2r$

$$U_i = \frac{2kP_1P_2}{r^3}$$

$$U_f = \frac{2kP_1P_2}{8r^3} = \frac{kP_1P_2}{4r^3}$$

finally

$$U_i - U_f = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$m_1v_1 = m_2v_2$$

$v_1 =$ ——

$v_2 =$ ——

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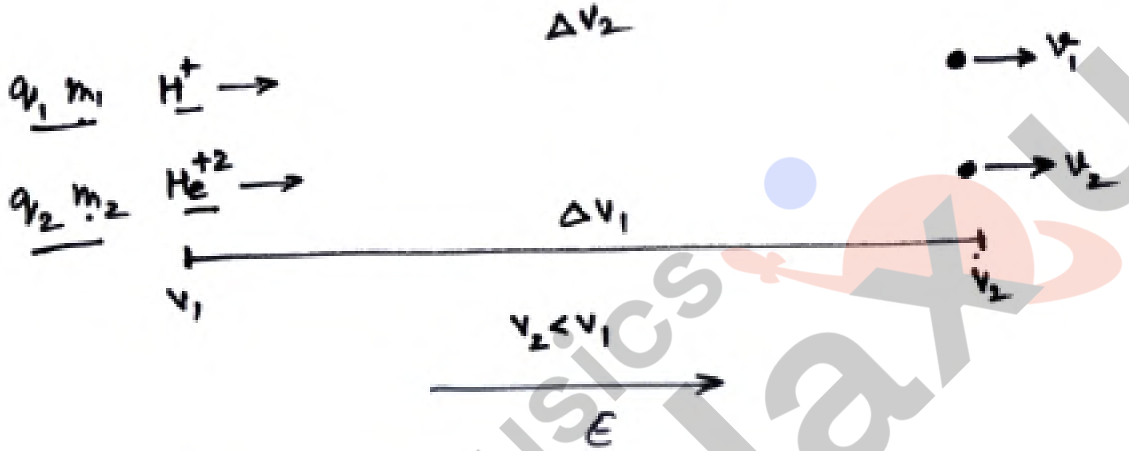
QUESTIONS BASED ON

TWO IONS ACCELERATED BY SAME POTENTIAL DIFFERENCE



W

$q_1(V_1 - V_2) = \frac{1}{2} m v_1^2$

$q_2(V_1 - V_2) = \frac{1}{2} m v_2^2$

$W = q\Delta V.$

If final KE are same then we use

$q_1 \Delta V_1 = q_2 \Delta V_2 \rightarrow \left[\frac{q_1}{q_2} = \frac{\Delta V_2}{\Delta V_1}\right]$

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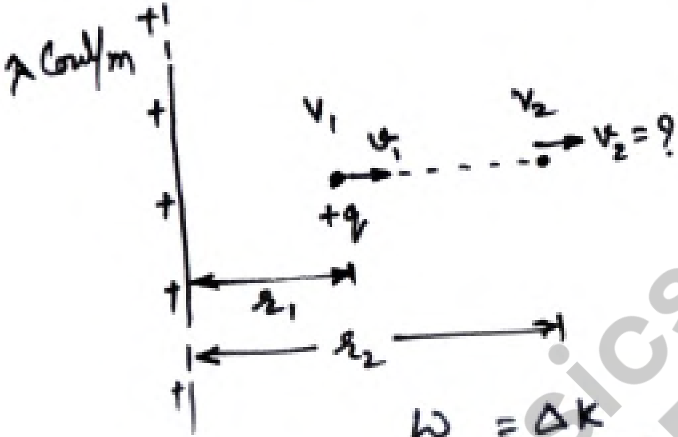
Questions Based on

Work Done by a Line Charge on Point Charge



$$V_1 - V_2 = \int_{r_1}^{r_2} E.dx = \int_{r_1}^{r_2} \frac{\lambda}{2\pi\epsilon_0 x}.dx$$

$$V_1 - V_2 = \frac{\lambda}{2\pi\epsilon_0} \ln(r_2/r_1)$$

$$W = \Delta K$$

$$q(V_1 - V_2) = \frac{1}{2} m (v_2^2 - v_1^2)$$

$$\frac{q\lambda}{2\pi\epsilon_0} \ln \frac{r_2}{r_1} = \frac{1}{2} m (v_2^2 - v_1^2)$$

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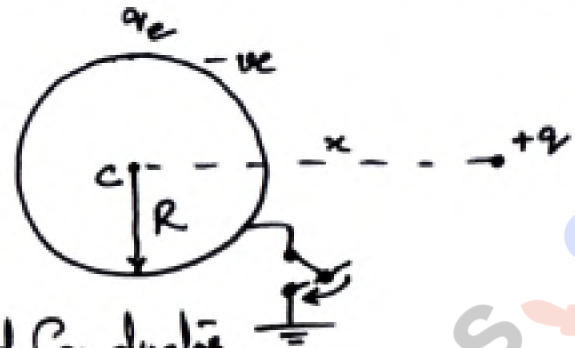
Questions Based on

Earthing of Spherical Shells



Earthed Conductor

$V_f = 0$

$$\frac{Kq}{x} + \frac{Kq_e}{R} = 0$$

$$q_e = -\frac{qR}{x}$$

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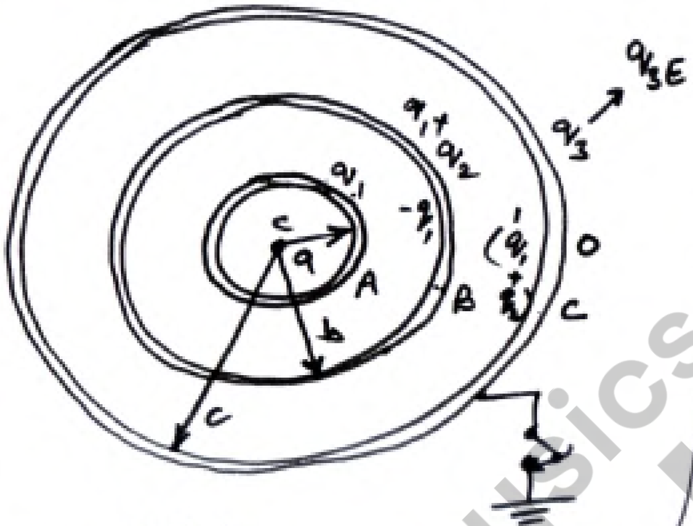
QUESTIONS BASED ON

EARTHING OF CONCENTRIC SHELLS



$$V_A = \frac{kq_1}{a} + \frac{kq_2}{b} + \frac{kq_3}{c}$$

$$V_B = \frac{kq_1}{b} + \frac{kq_2}{b} + \frac{kq_3}{c}$$

$$V_C = \frac{k(q_1+q_2+q_3)}{c}$$

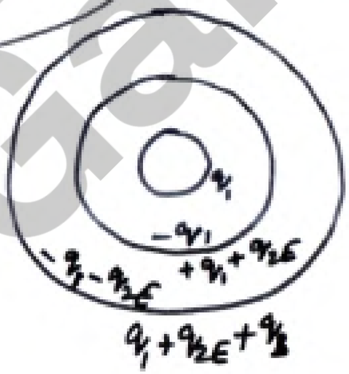
$$V_{C\,new} = \frac{k(q_1+q_2+q_{3E})}{c} = 0$$

$$q_{3E} = -(q_1+q_2)$$

If B is earthed

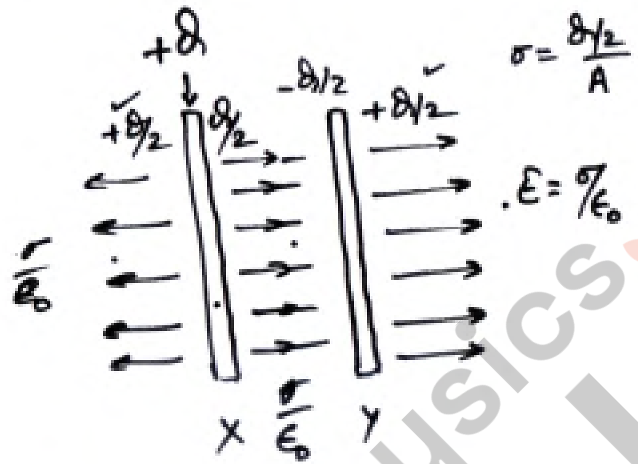
$$\frac{q_1+q_{2E}}{b} + \frac{q_3}{c} = 0$$

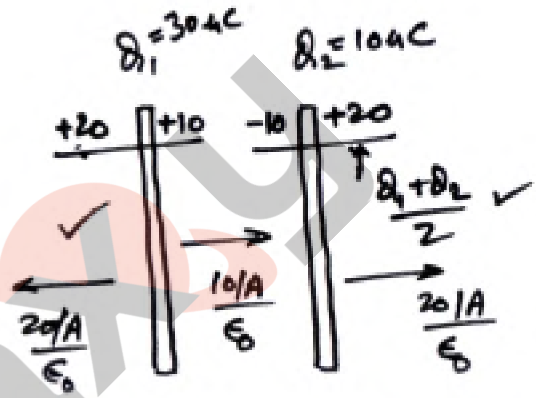
$$q_{2E} = -b\left[\frac{q_3}{c} + \frac{q_1}{b}\right]$$

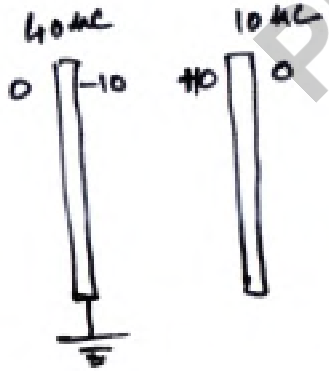


Questions Based on

Charge Distribution & Field Configuration in Parallel Plates







QUESTIONS BASED ON

CONNECTING TWO CONDUCTING SPHERES

$$V_{1f} = V_{2f}$$

$$Q_1 + Q_2 = q_{1f} + q_{2f}$$

$$\frac{kq_{1f}}{R_1} = \frac{kq_{2f}}{R_2}$$

$q_{1f} = \_\_\_\_$

$q_{2f} = \_\_\_\_$

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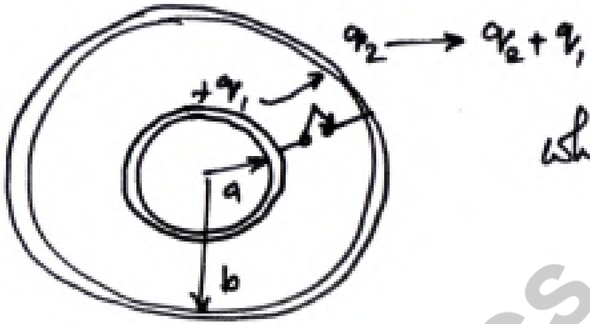
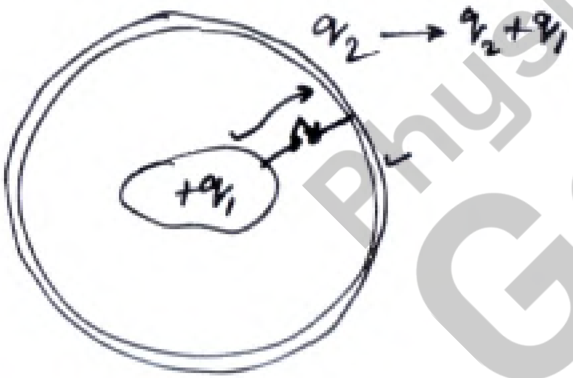
Questions Based on

Connecting Concentric Shells



Whole charge flows to outer shell



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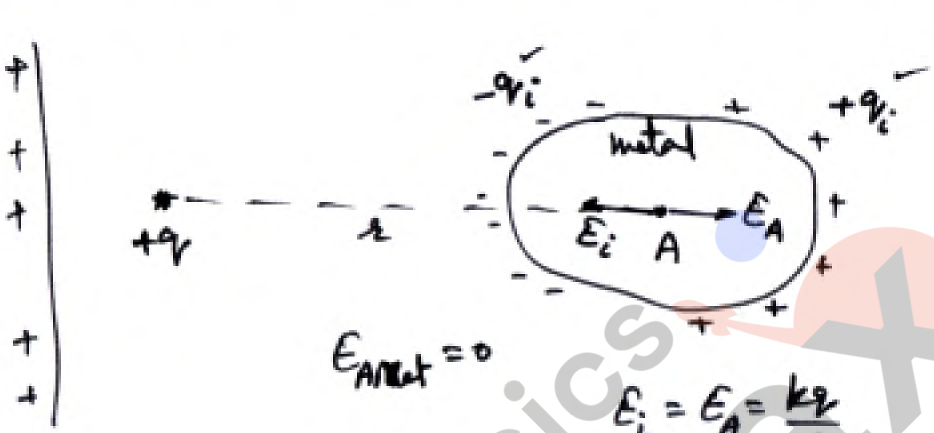
QUESTIONS BASED ON

ELECTRIC FIELD DUE TO INDUCED CHARGES ON METAL BODY



$E_{A\,net} = 0$

$E_i = E_A = \frac{kq}{r^2}$

$\vec{E}_i = -\vec{E}_{ext}$

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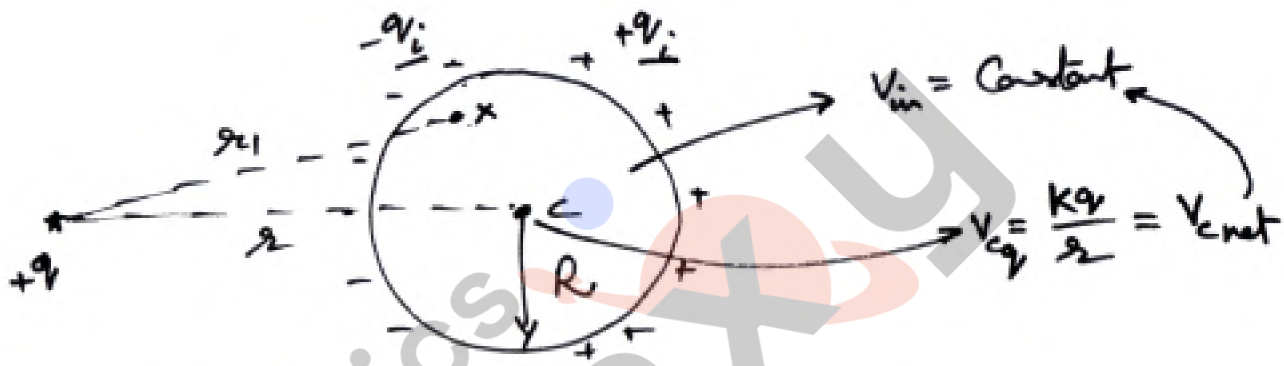
Questions Based on

Potential Due to Induced Charges on a Metal Body



$$V_{c_i} = 0$$

$$V_{xq} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r_1}$$

$$V_x = V_{cnet} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r_1} + V_i$$

$$\Rightarrow V_i = kq\left[\frac{1}{r} - \frac{1}{r_1}\right]$$

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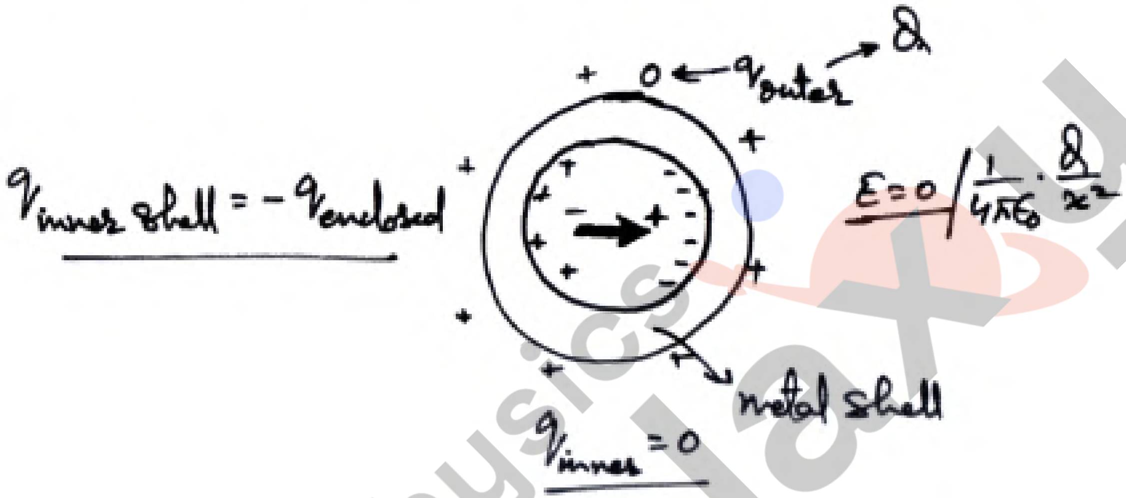
Questions Based on

Induced Charges in a Shell Due to a Dipole



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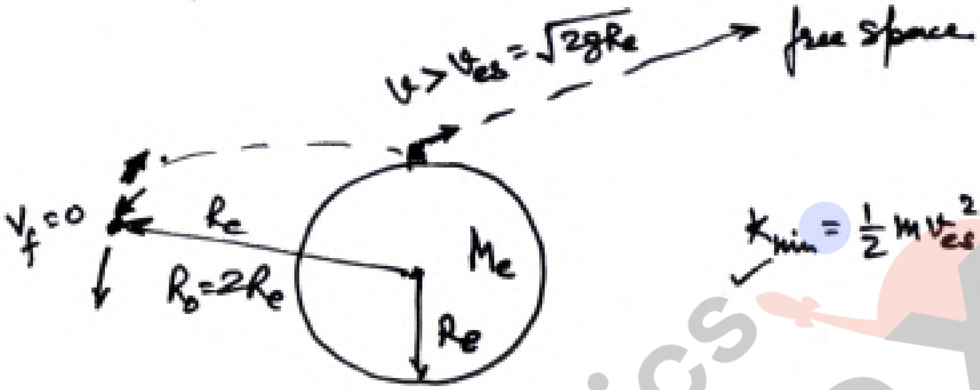
Questions Based on

Energy Required to Launch a Spaceship



$$K_{min} = \frac{1}{2} m v_{es}^2 = \frac{1}{2} m (2gR_e) = mgR_e$$

Energy reqd to raise the spaceship to R_0.

$$K_i + P_i = P_f$$

$$\frac{1}{2} m v^2 - \frac{GM_e m}{R_e} = -\frac{GM_e m}{R_0}$$

$$v = \_\_\_\_$$

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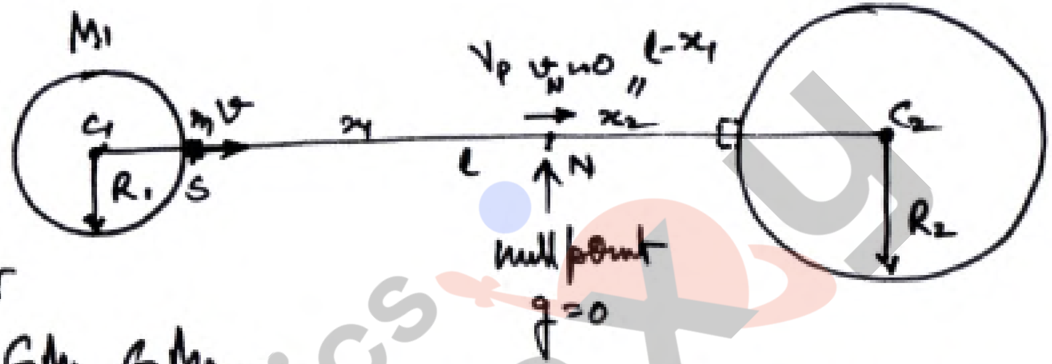
Questions Based on

Transferring a Body From One Planet to Another



Pot^n of null pt

$$V_P = -\frac{GM_1}{x_1} - \frac{GM_2}{x_2}$$

$$\frac{GM_1}{x_1^2} = \frac{GM_2}{(l-x_1)^2} \rightarrow x_1 = \text{—}$$

using energy Cons from S to N

$$\frac{1}{2}mv^2 - \left(\frac{GM_1}{R_1} - \frac{GM_2}{l-R_1}\right)m = -mV_P$$

$$v = \text{—}$$

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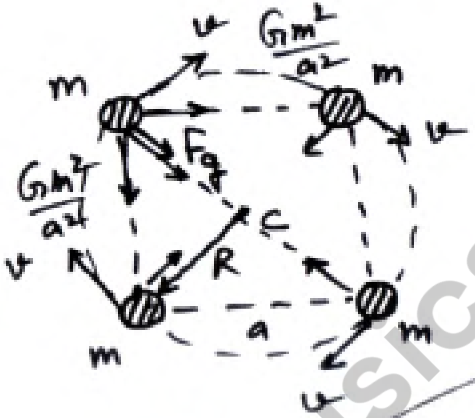
QUESTIONS BASED ON

REVOLUTION OF FOUR PARTICLES UNDER GRAVITATIONAL FORCE



$$f_g = \frac{\sqrt{2}Gm^2}{a^2} + \frac{Gm^2}{2a^2} = \frac{mv^2}{(a/\sqrt{2})}$$

$v =$ —

$R = \frac{a}{\sqrt{2}}$

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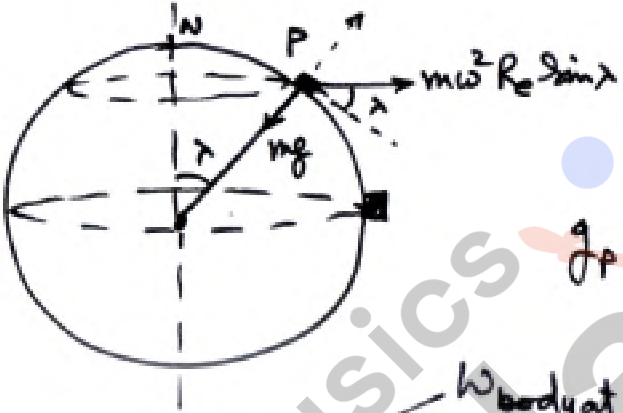
QUESTIONS BASED ON

EFFECT OF ROTATION OF EARTH ON WEIGHT OF BODIES



$$g_P = g_s - \omega^2 R_e \sin^2\lambda$$

if $\omega_e \longrightarrow 3\omega_e$

$W_{\text{body at } N} \longrightarrow$ remain

$W_{\text{equator}} \longrightarrow$

$$g_i = g_s - \omega^2 R_e$$

$$g_f = g_s - 9\omega^2 R_e$$

at a particular λ, we use

$$g_P = \frac{g_{Pi}}{5} = g - 9\omega^2 R_e \sin^2\lambda$$

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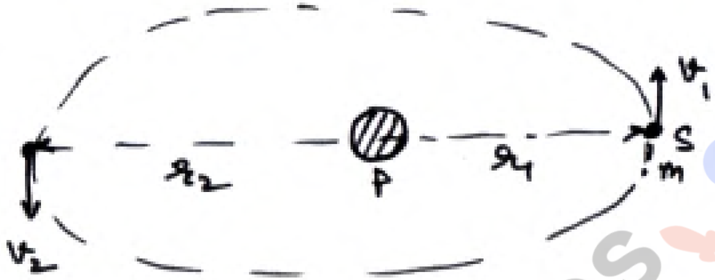
QUESTIONS BASED ON

PERIGEE & APOGEE RELATION IN ELLIPTICAL PATH



$$m v_1 r_1 = m v_2 r_2$$

$$\frac{1}{2} m_1 v_1^2 - \frac{GMm}{r_1} = \frac{1}{2} m v_2^2 - \frac{GMm}{r_2}$$

$$T^2 = \frac{4\pi^2}{GM}\left(\frac{r_1 + r_2}{2}\right)^3$$

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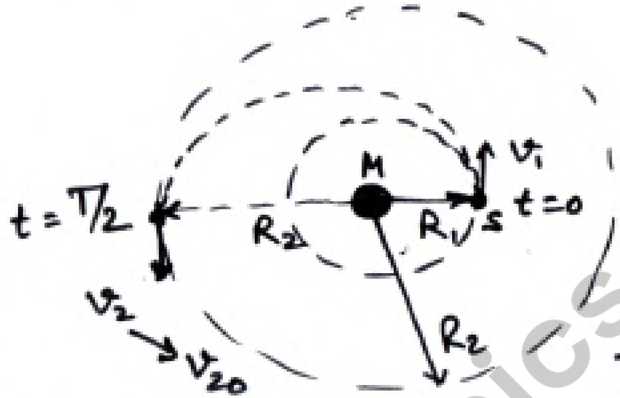
QUESTIONS BASED ON

CHANGING ORBIT OF A SETELLITE IN ELLIPTICAL PATH



$v_1 \leftarrow v_{10} = \sqrt{\frac{GM}{R_1}}$

$v_2 \rightarrow v_{20} = \sqrt{\frac{GM}{R_2}}$

$a = \frac{R_1+R_2}{2}$

time of elliptical orbit $T^2 = \frac{4\pi^2}{GM} a^3$

time of orbit transfer

$t = T/2$

for elliptical path

$\frac{1}{2}mv_1^2 - \frac{GMm}{R_1} = \frac{1}{2}mv_2^2 - \frac{GMm}{R_2}$

$v_1 R_1 = v_2 R_2$

$v_1 =$ ——

$v_2 =$ ——

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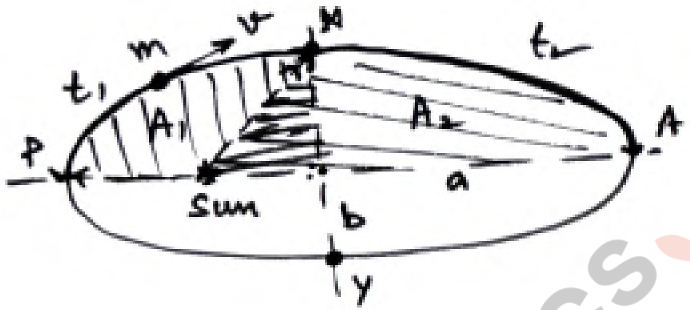
Questions Based on

Time to cover an Elliptical Arc By a Satellite or a Planet



Areal vel → Const

area of ellipse $= \pi ab$

$$A_1 = \frac{\pi ab}{4} - A_T$$

$$A_2 = \frac{\pi ab}{4} + A_T$$

$$\frac{t_1}{t_2} = \frac{A_1}{A_2} =$$

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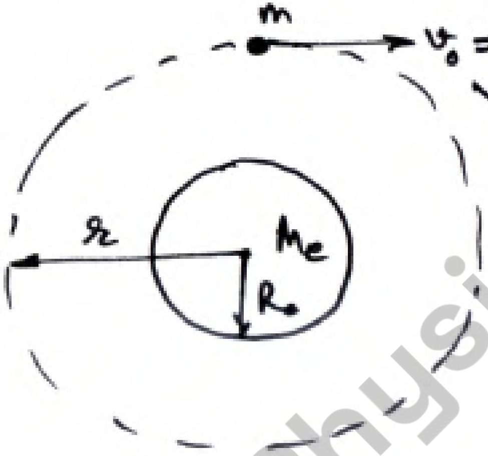
QUESTIONS BASED ON

ESCAPING OF A SATELLITE



$v_0 = \sqrt{\frac{GM}{r}}$

$v_{es} = \sqrt{2}\, v_0$

To free from gravity

$E_{ts} = 0$

$\frac{1}{2} m v_{es}^2 - \frac{GMm}{r} = 0$

$v_{es} = \sqrt{\frac{2GM}{r}}$

$\left(\frac{v_{es}}{v_0} = \sqrt{2} \right) \rightarrow 1.414\, v_0$

41.4% inc.

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