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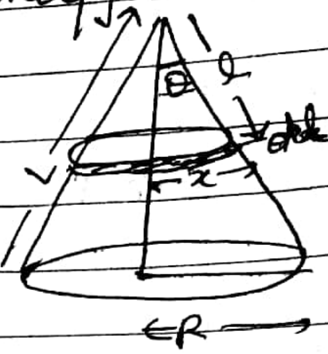
Electrostatic

Q.1 Find the total Potential due to cone and also find the energy also.



Ans: Consider the cone to be made up of large no of elementary rings. Consider the thickness dl and radius x of elementary ring. R is the radius of cone.

So $dQ = \sigma\, dA$ $\qquad dA = 2\pi x\, dl$

Surface Area of cone $= \pi R L$

So $dQ = \dfrac{Q}{\pi R L} \times 2\pi x\, dl$ $\qquad x = l \sin\theta$

$$dQ = \frac{2Qx\, dl}{RL}$$

$$dQ = \frac{2Ql \sin\theta\, dl}{RL}$$

Potential at O due to this ring

$$dV = \frac{1}{4\pi\varepsilon_0}\frac{dQ}{l}$$

$$dV = \frac{Q\sin\theta}{2\pi\varepsilon_0 RL}\, dl$$

The Total Potential at O

$$V = \frac{Q\sin\theta}{2\pi\varepsilon_0 RL}\int_0^L dl$$

$$= \frac{QL\sin\theta}{2\pi\epsilon_0 RL}$$

$$= \frac{Q}{2\pi\epsilon_0 L}$$

Then $U = qV$

$$= \frac{Qq}{2\pi\epsilon_0 L}$$

Q.2 Find the flux through the following figure.

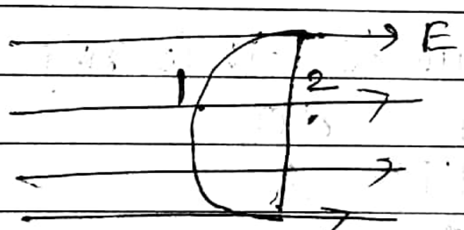
(a)

Solution: As net charge in hemisphere inside is zero

$\phi_1 + \phi_2 = 0$ But E ‖ to surface 2

$\phi_2 = 0, \phi_1 = 0$

(b)



$\phi_1 \rightarrow$ incoming

$\phi_2 =$ outgoing

Again $\phi_1 + \phi_2 = 0$

$\phi_2 = E \times \pi R^2$

$\phi_1 = -\phi_1$

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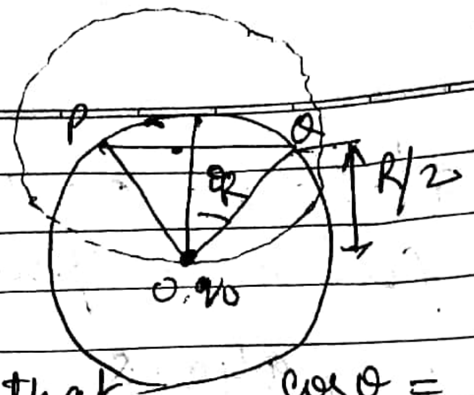
Part c



we know that $\cos\theta = \frac{R/2}{R}$

$= 60^\circ$

$\angle POQ = 2\theta$

$= 2 \times 60$

$= 120$

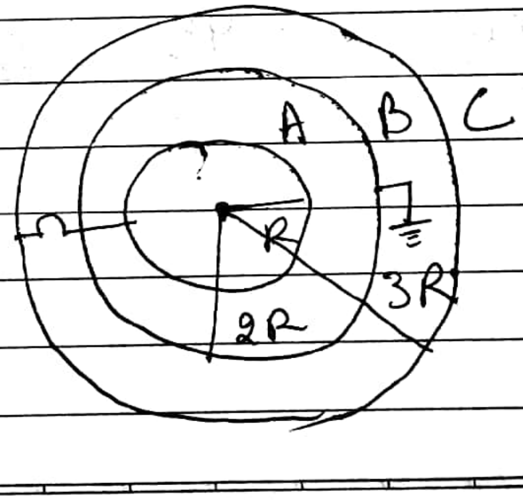
Length of Arc $= \frac{2\pi}{3} R$

charge inside sphere $= \frac{q_0}{2\pi R} \times \frac{2\pi}{3} R$

$= \frac{q_0}{3}$

Net flux $= \frac{q_0}{3\varepsilon_0}$ Ans.

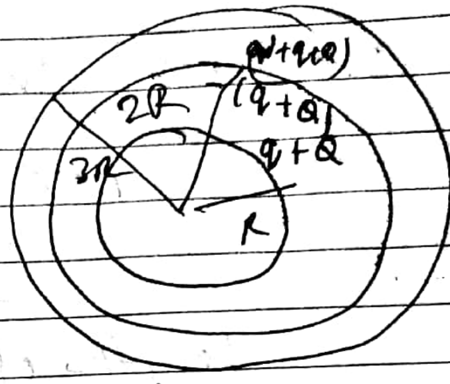
Question Find the charge ~~on~~ the following concentric sphere shown in fig



Solution:

Let q' = charge on sphere B and charge flow from sphere $C \to A$.

$$V_B = \frac{1}{4\pi\epsilon_0}\left(\frac{q'+q+Q}{2R} + \frac{2q-Q}{3R}\right)$$



$$V_C = \frac{1}{4\pi\epsilon_0}\frac{3q+q'}{3R}$$

$$V_P = \frac{1}{4\pi\epsilon_0}\left(\frac{q+Q}{R} + \frac{q}{2R} + \frac{2q-Q}{3R}\right)$$

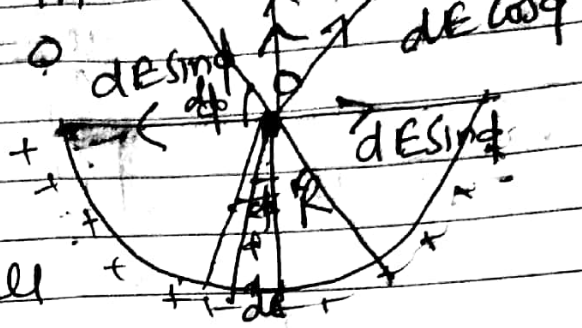
$$4q + 4q + q' = 0$$

$$Q = -\frac{5}{11}q$$

$$q' = -\frac{24}{11}q$$

A	B	C	
$-q$	$-2q$	$\frac{4}{3}q$	charge on inner surface.
$+2q$	$-\frac{4q}{3}$	$\frac{2}{3}q$	charge on outer surface

Q. Find the electric field due to ring shape fig shown in below find the electric field at O



Ans: taken an elementary portion of the ring of small portion length dl and angle dφ so we have to find the charge (small)

$$dq = \lambda dl = \lambda R d\phi \qquad dl = Rd\phi$$

so symmetrically $dq = \lambda dl = \lambda R d\phi$

$$dE = \frac{1}{4\pi\epsilon_0}\frac{dq}{R^2}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{\lambda d\phi}{R}$$

dE sinφ cancel and dE cosφ will be added Result to integration

net field at O

$$E = \int dE \cos\phi$$

$$= \int_{-\pi/2}^{+\pi/2} \frac{1}{4\pi\epsilon_0}\frac{\lambda}{R}\cos\phi\, d\phi$$

$$= \frac{1}{4\pi\epsilon_0}\frac{2\lambda}{R}$$

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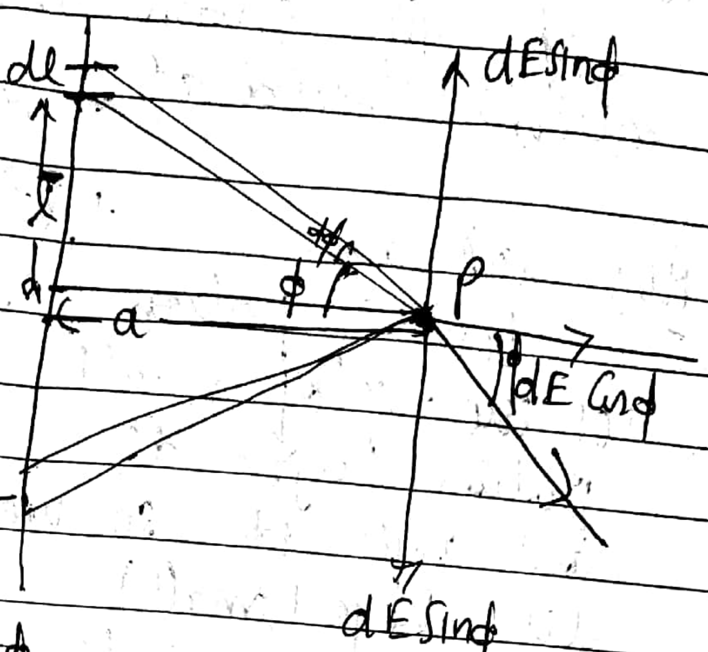
Q. Similar fig can change into Rod like problem.



$$dq = \lambda\, dl = \frac{Q}{L}\, dl$$

$$dE = \frac{1}{4\pi\varepsilon_0} \frac{dq}{(a\sec\phi)^2} = \frac{1}{4\pi\varepsilon_0} \frac{Q\,dl}{La^2\sec^2\phi}$$

$l = a\tan\phi$

$dl = a\sec^2\phi\, d\phi$

$$dE = \frac{1}{4\pi\varepsilon_0} \frac{Q\,dl}{La^2\sec^2\theta} = \frac{1}{4\pi\varepsilon_0} \frac{Q \times a\sec^2\phi\, d\phi}{La^2}$$

$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q\,d\phi}{La}$$

Net electric field at P

$$E = \int_{0} dE\cos\phi = \int_{-\theta}^{\theta} \frac{1}{4\pi\varepsilon_0} \frac{Q\,d\phi}{La} = \frac{1}{4\pi\varepsilon_0} \frac{2Q\sin\theta}{La}$$

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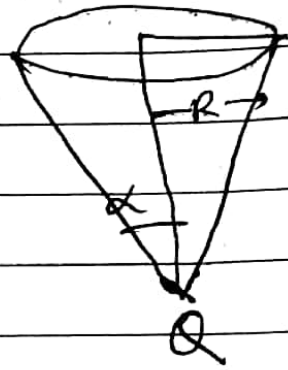
But $\sin\theta = \dfrac{L}{2\sqrt{a^2+\left(\frac{L}{2}\right)^2}}$

$$= \frac{L}{\sqrt{4a^2+L^2}}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{2Q}{a\sqrt{4a^2+L^2}}$$

Question Consider the charge is placed at vertex of the cone of height b and radius R

α is the semi vertex angle =



So solid angle

$$\Omega = 2\pi(1-\cos\alpha)$$

Flux passing through cone

$$\phi = \frac{\Omega}{4\pi}\phi_{total} \text{ (given)}$$

$$\phi = 2\pi(1-\cos\alpha) = \pi$$

$$1-\cos\alpha = 1/2$$

$$\cos\alpha = \frac{1}{2}$$

$$\alpha = \pi/3$$

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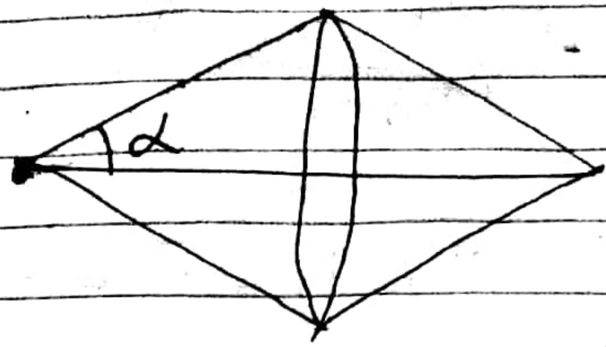
Question Find the flux through the following figure



$\phi_1 = \phi_2 =$

$= \frac{\Omega}{4\pi} \times \phi\ \text{total}$

$= \frac{2\pi(1-\cos\alpha)}{4\pi} \times \frac{q}{\varepsilon_0}$

$= \frac{1}{2\varepsilon_0} q (1-\cos\alpha)$

Total flux through the surface $\phi = \phi_1 + \phi_2$

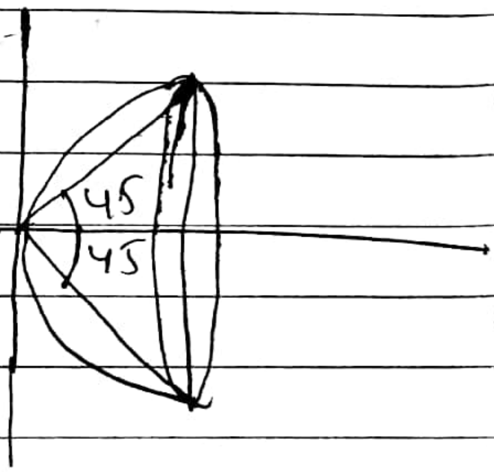
$= \frac{q}{\varepsilon_0}(1-\cos\alpha)$

$= \frac{q}{\varepsilon_0}\left(1 - \frac{l}{\sqrt{R^2+l^2}}\right)$

Question Find the flux through the hemisphere

Radius of hemisphere $= a$

So Solid angle



$\Omega = 2\pi(1-\cos\alpha)$

$= 2\pi\left(1 - \frac{1}{\sqrt{2}}\right)$

$\phi = \frac{\Omega}{4\pi} \times \phi\ \text{total}$

$= \frac{q}{2\varepsilon_0}\left(1 - \frac{1}{\sqrt{2}}\right)$

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