Nishant Jindal

Conductor

Properties of Conductors

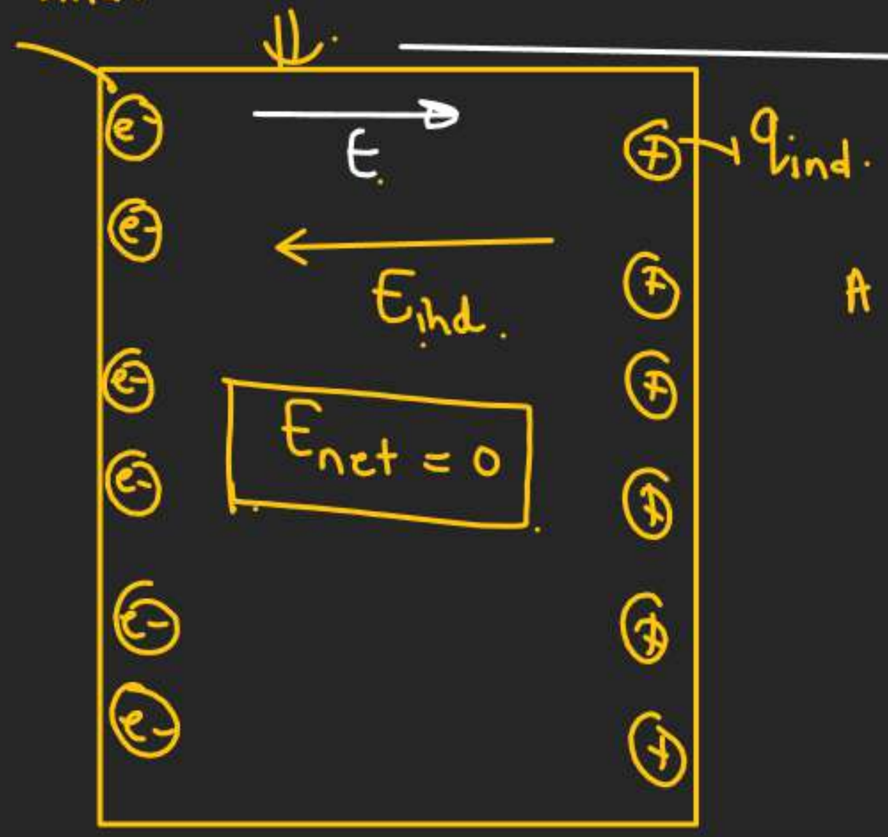
❖ $E_{net} = 0$ inside the conductor

$\boxed{E_{ind} = E}$

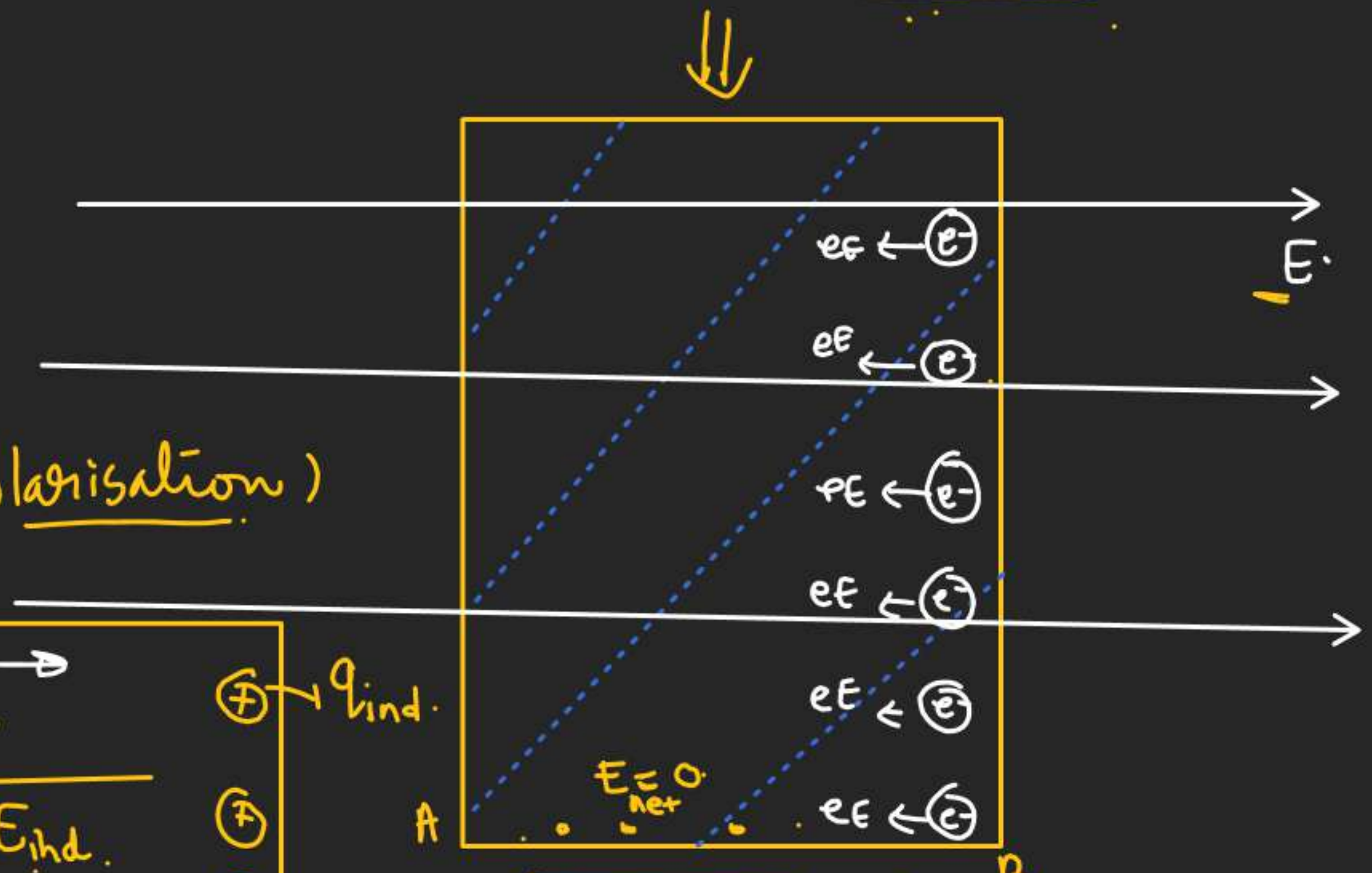
⇓

For Conductors

(Polarisation)



Conducting plate



$\boxed{V_A = V_B} \Rightarrow$ (Inside potential constant)

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Conductor

❖ **Electric potential (V) is constant throughout a conductor**

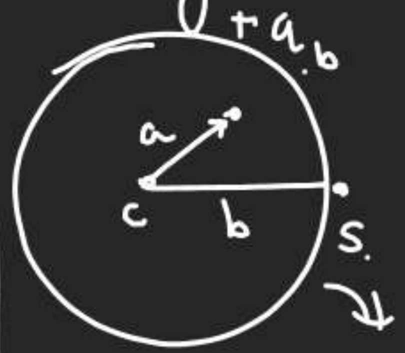
↳ Potential due to Concentric thin Shell

q_a, q_b & q_c are the Charges on the Conducting Shells.

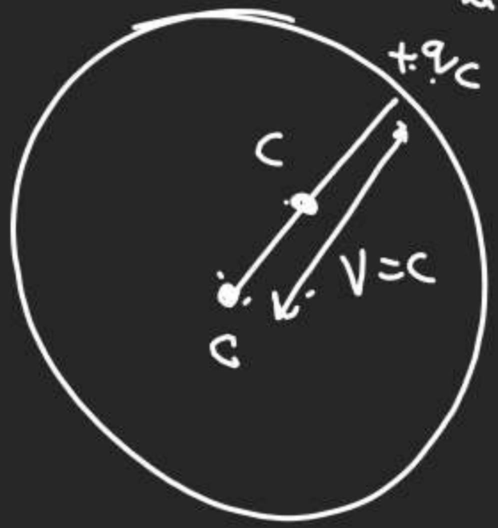
$$V_1 = \left[\frac{Kq_a}{a} + \frac{Kq_b}{b} + \frac{Kq_c}{c}\right]$$

$$V_2 = \left[\frac{Kq_a}{b} + \frac{Kq_b}{b} + \frac{Kq_c}{c}\right]$$

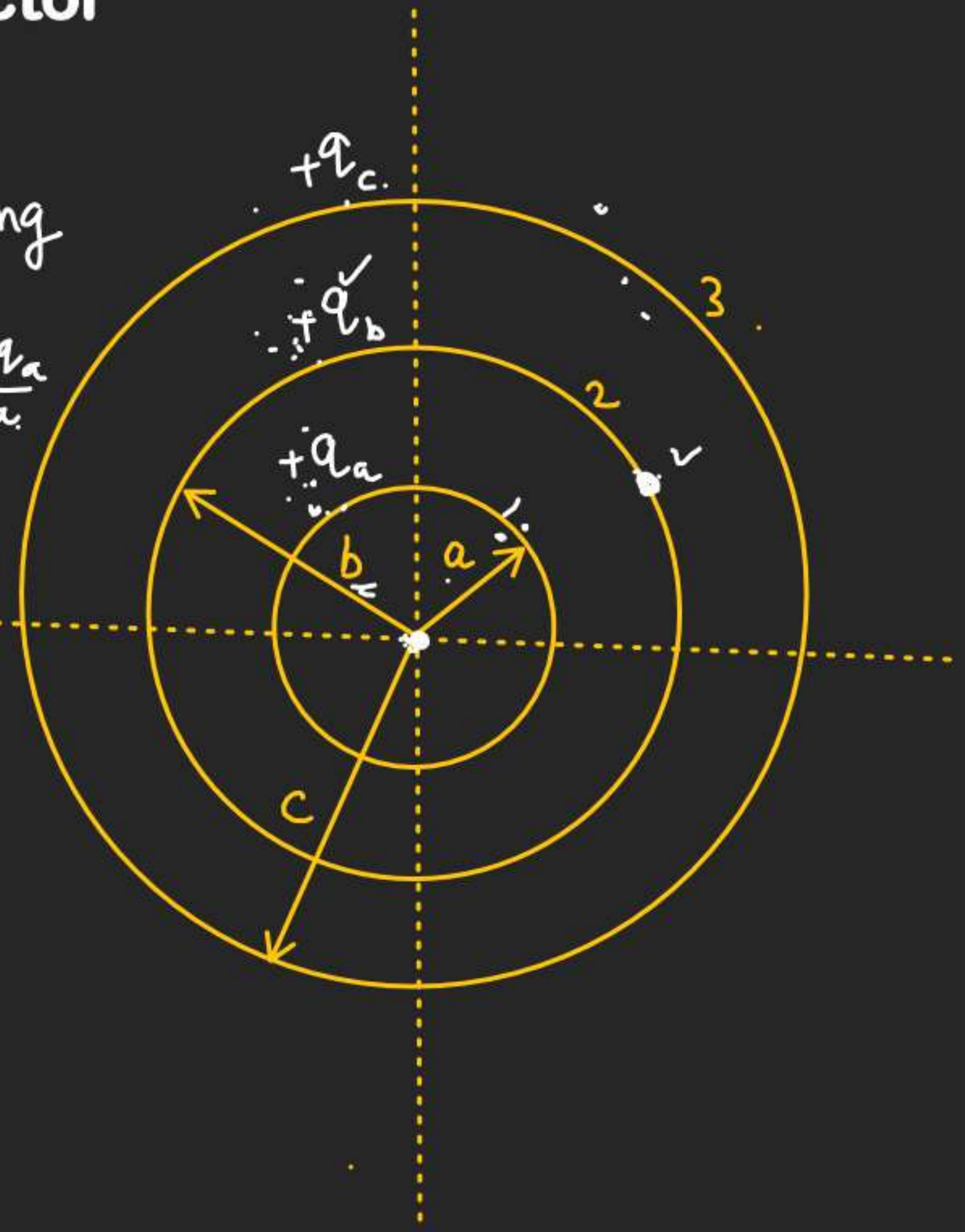
$$V_3 = \left[\frac{Kq_a}{c} + \frac{Kq_b}{c} + \frac{Kq_c}{c}\right]$$



$$V_c = V_a = V_s = \frac{Kq_b}{b}$$



$\frac{Kq_a}{a}$



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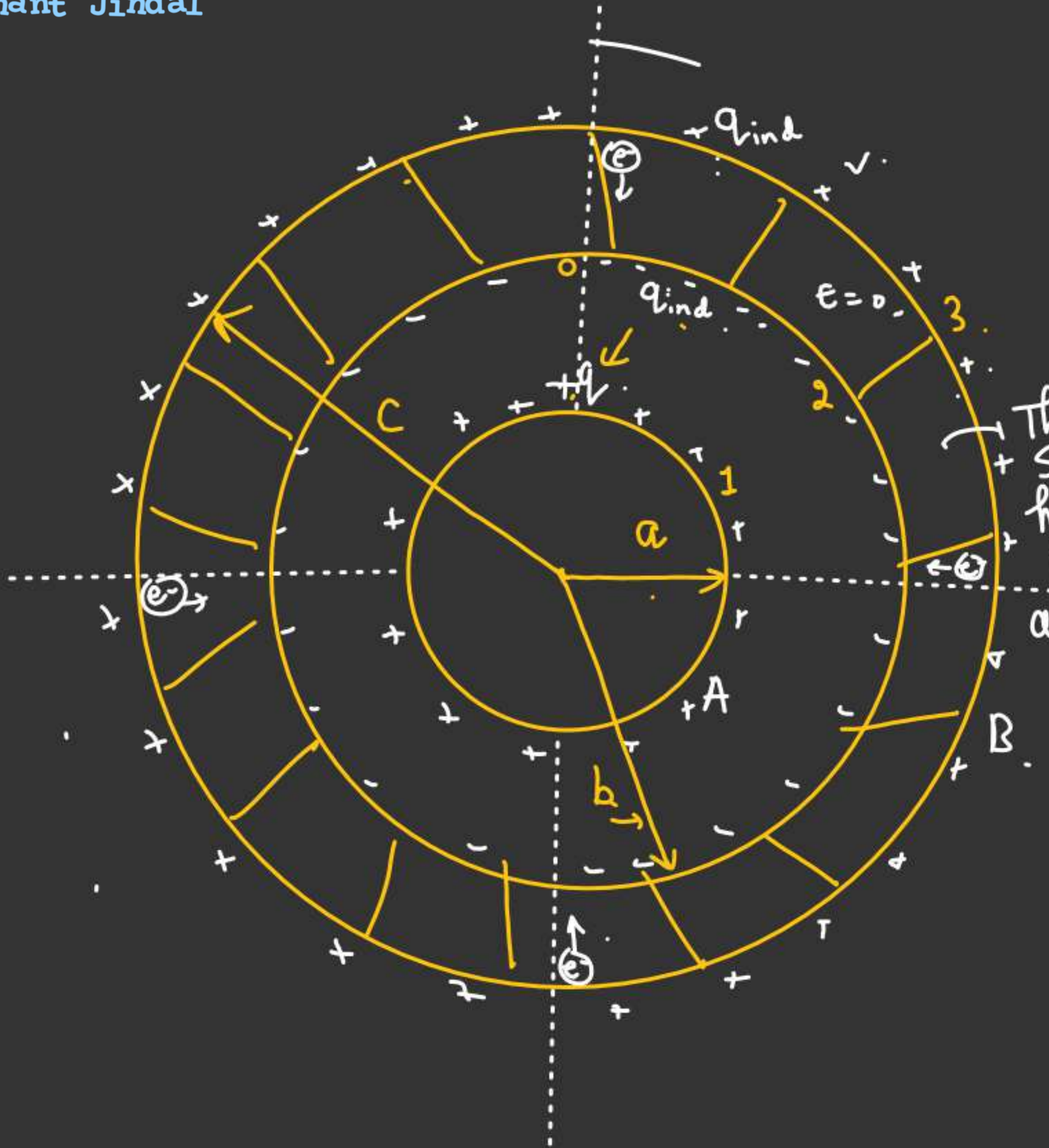
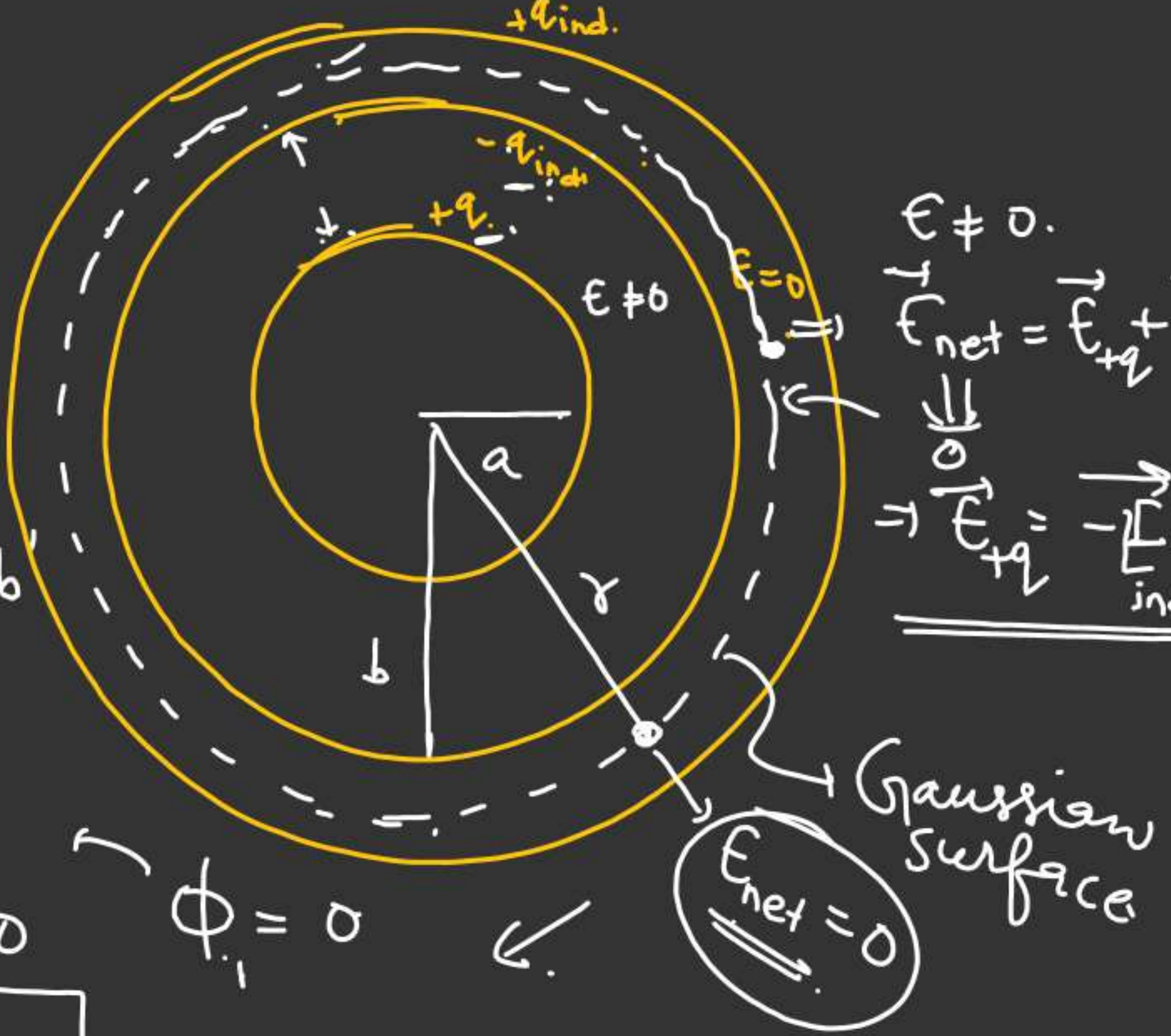


Thick Shell having inner radius 'a' and outer radius 'b'

$$(q_{enc}) = 0$$
$$\Downarrow$$
$$+q - q_{ind} = 0$$
$$\boxed{q = q_{ind}}$$

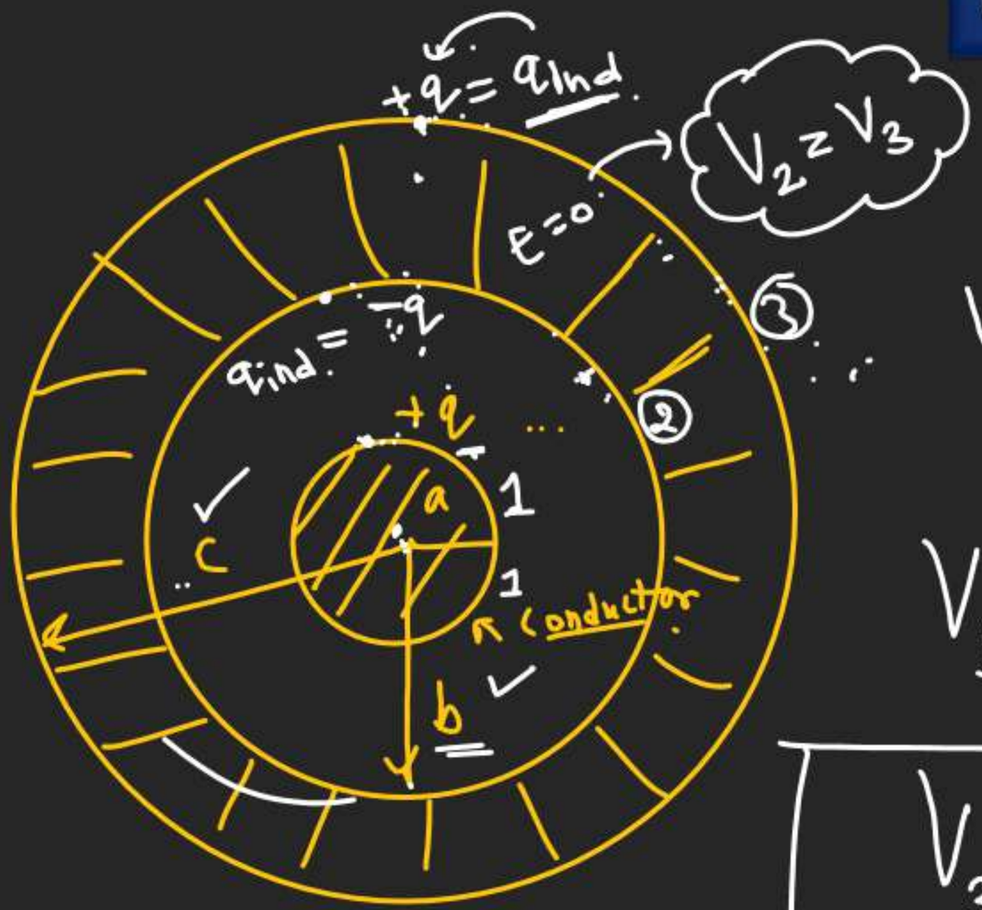
$$\phi = 0$$



$E \neq 0.$

$$\vec{E}_{net} = \vec{E}_{+q} + \vec{E}_{q_{ind}}$$
$$\Downarrow$$
$$0$$
$$\Rightarrow \vec{E}_{+q} = -\vec{E}_{ind}$$

Conductor



$$V_1 = \left[\frac{Kq}{a} - \frac{Kq}{b} + \frac{Kq}{c}\right]$$

$$V_3 = \cancel{\frac{Kq}{c}} - \cancel{\frac{Kq}{c}} + \frac{Kq}{c}$$

$$\boxed{V_3 = \frac{Kq}{c}}$$

$$\Rightarrow V_2 = V_3 \Rightarrow E = 0, \quad V = C$$

$$V_2 = \cancel{\frac{Kq}{b}} - \cancel{\frac{Kq}{b}} + \frac{Kq}{c}$$

Thin Shell ⇒

$$V_A = \frac{Kq_a}{a} - \cancel{\frac{Kq_a}{b}} + \cancel{\frac{Kq_a}{b}}$$

$$\boxed{V_A = \frac{Kq_a}{a}}$$

Note :- For thin spherical shell doesn't consider the potential due to Induces charge

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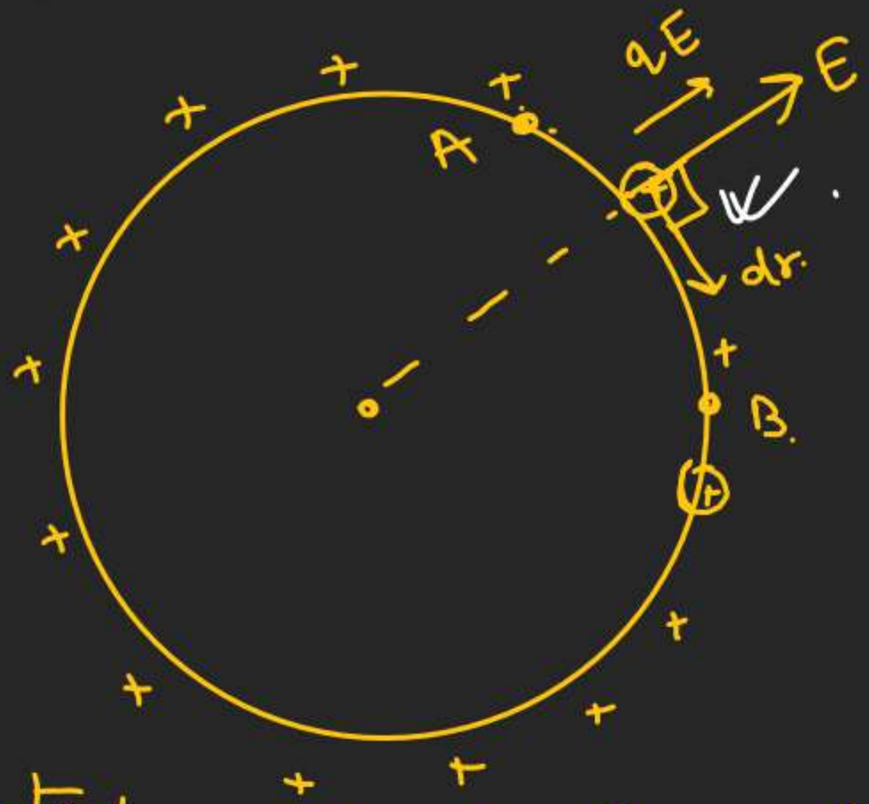
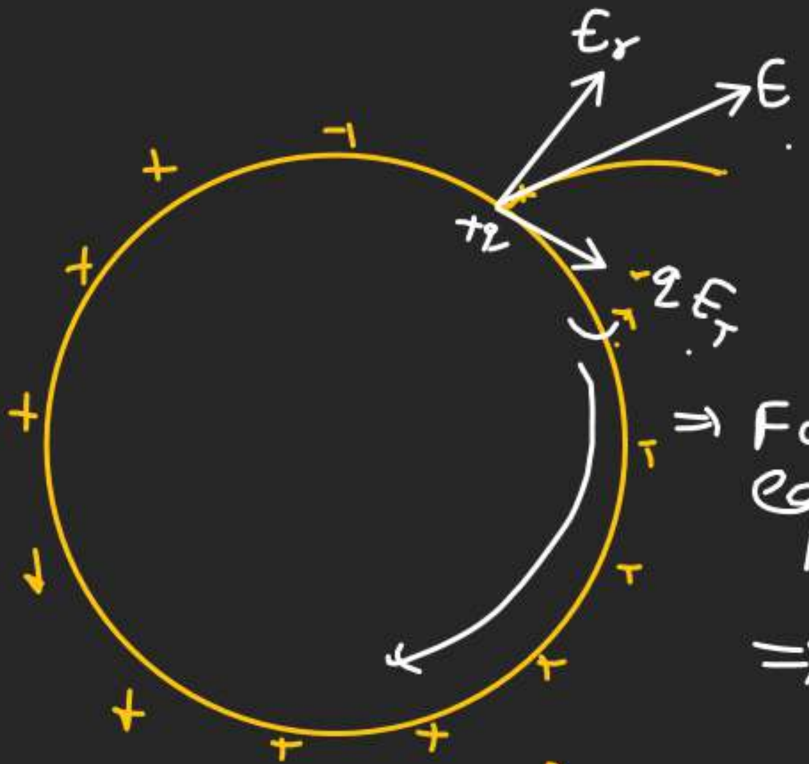
Conductor

❖ E is perpendicular to the Surface of just outside the conductor.





If a charge is given to a conductor it will redistribute on the surface in such a way so that surface become equipotential

⇒ For Electrostatic equilibrium

$q E_T = 0$

⇒ E should be radial

Note :- The Surface of the Conductor always equipotential

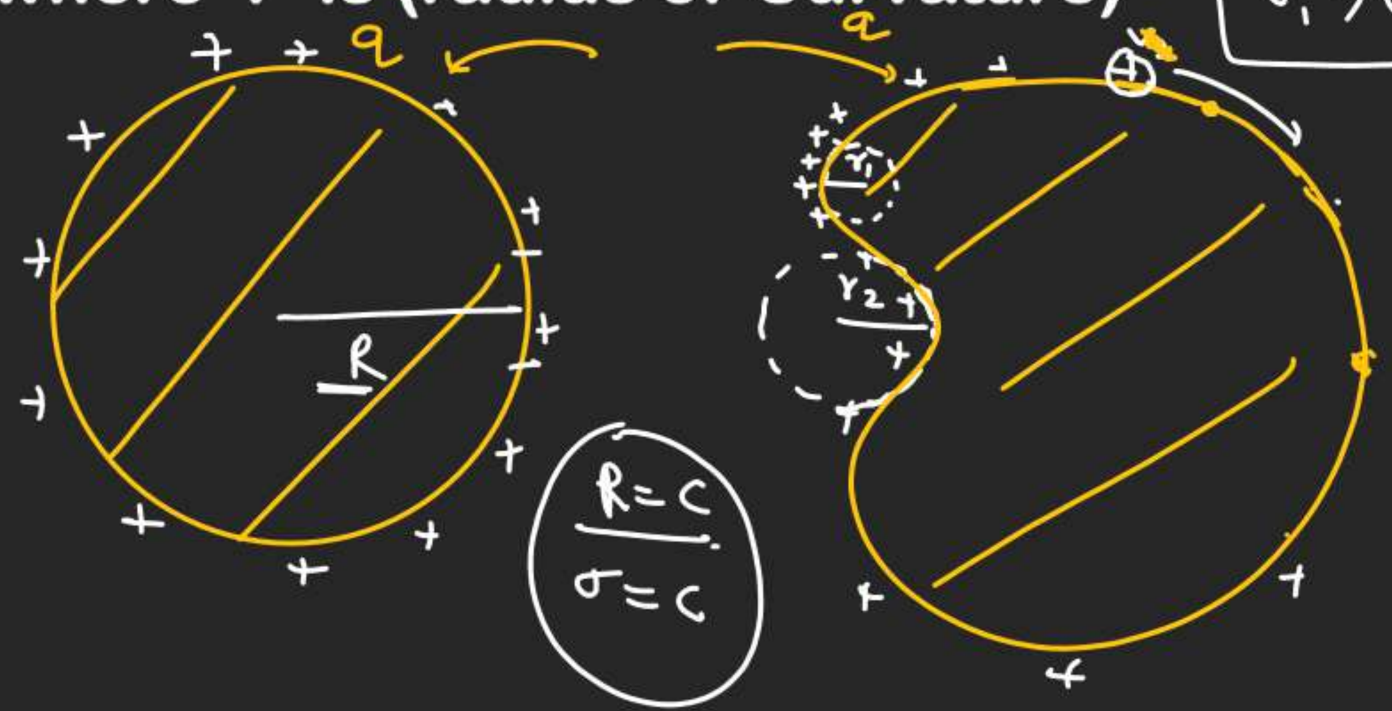
$\vec{E} \perp dr$

$dV = 0 \Rightarrow \boxed{V_A = V_B}$

Conductor

❖ Charge density (σ) at a point on the surface of a conductor is in versly proportional to the radius of Curvature of the conductor at that point. $\boxed{\sigma \propto \frac{1}{r}}$

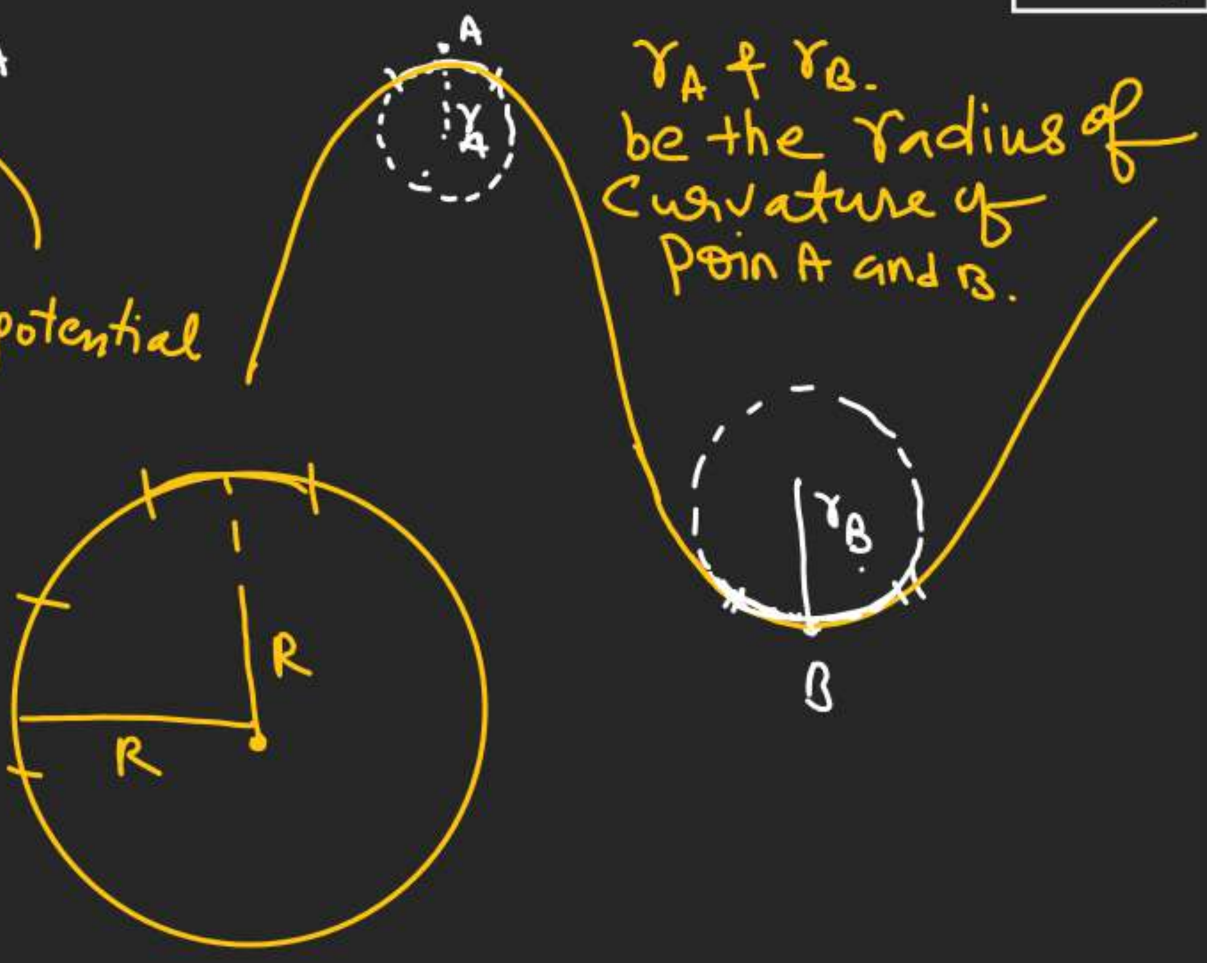
where 'r' is (radius of Curvature)



$\boxed{\begin{array}{c} r_1 < r_2 \\ \sigma_1 > \sigma_2 \end{array}}$

r_A

Equipotential



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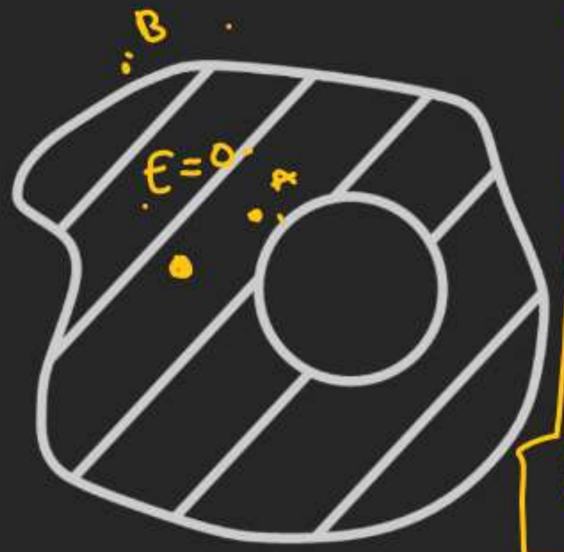
Conductor

❖ Cavity in a Conductor

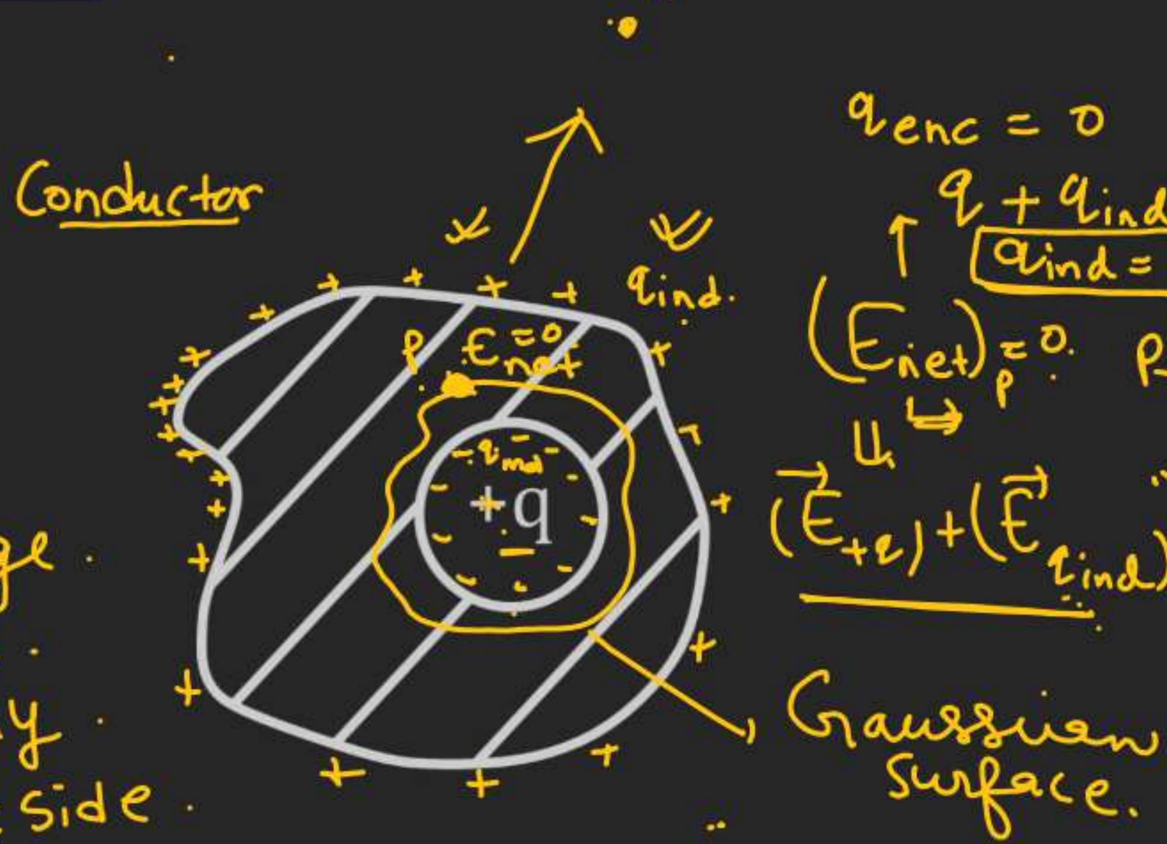
$V_A = V_B = 0$

$\boxed{q = 0}$



Cavity without charge

Note:-
Field or potential due to charge inside the cavity at any point outside the cavity is cancelled out by induced charge at the surface of the cavity.



Cavity with charge

$q_{enc} = 0$

$q + q_{ind} = 0$

$\boxed{q_{ind} = -q}$

$(E_{net})_P = 0$ P → inside point of a conductor

$(\vec{E}_{+q})_P + (\vec{E}_{q_{ind}})_P = 0$

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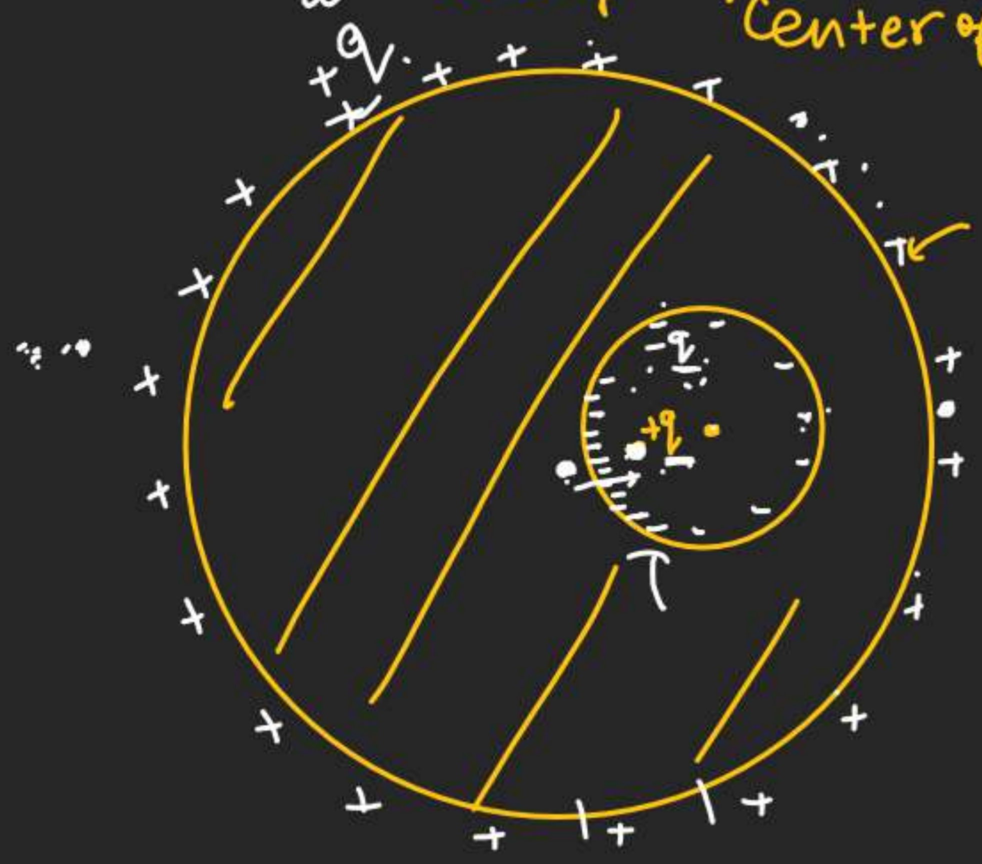
Conductor

(v) Charge '+q' not at the Center of the Cavity



↳ Inside the Cavity induced Charge in non-uniformly distributed.

↳ Induced Charge at the Surface of the Conductor is uniformly distributed to make the surface to become equipotential.

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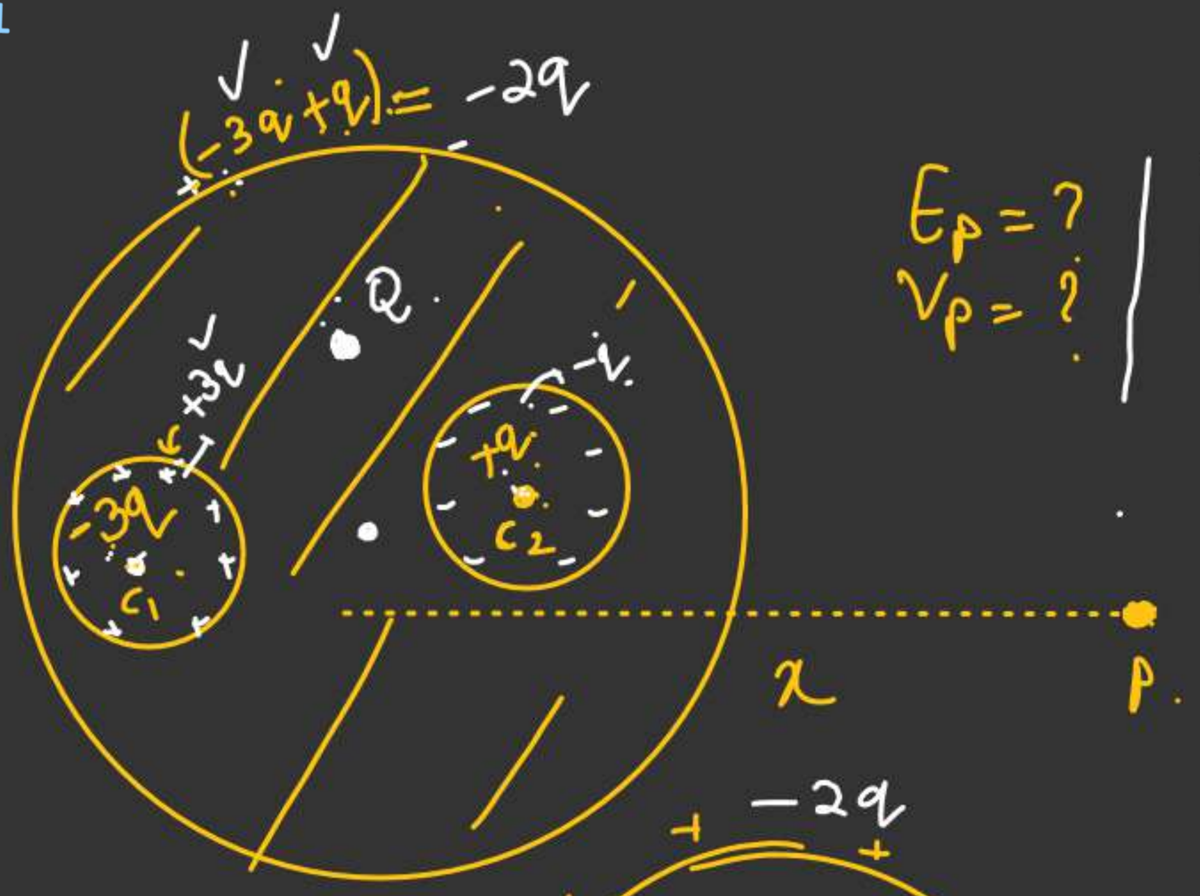
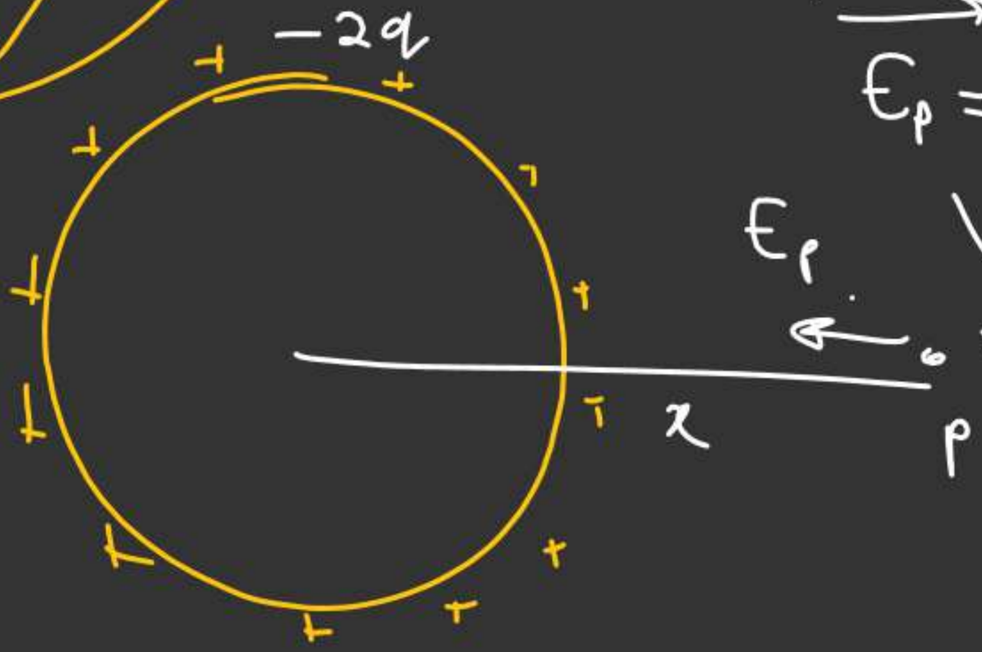


$E_P = ?$

$V_P = ?$

$\boxed{E_Q = 0}$

net field



$E_P = -\frac{K2q}{x^2}\hat{i}$ ✓

$V_P = \left(\frac{K(-2q)}{x}\right)$ ✓

only due to Charge at the outer surface of the conductor

Conductor

H.W.

A conducting sphere of radius R has two spherical cavities of radius a and b. The cavities have charges q_a and q_b respectively at their centres. Find:

(a) The electric field and electric potential at a distance r

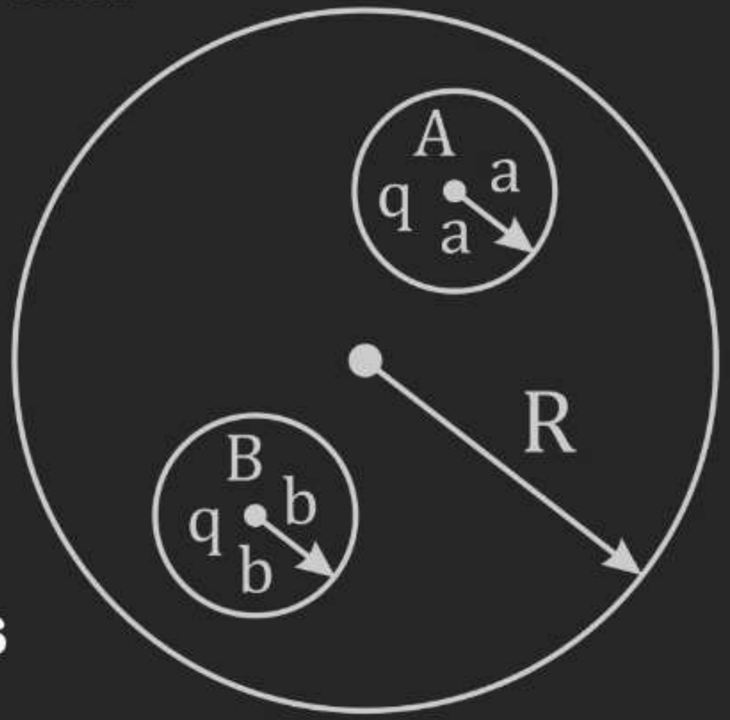
(i) r (distance from O, the centre of sphere $> R$)

(ii) r (distance from B, the centre of cavity b) $< b$

(iii) r inside sphere but out side cavities.

(b) Surface charge densities on the surface of radius R, radius a and radius b.

(c) What is the force on q_a and q_b ?



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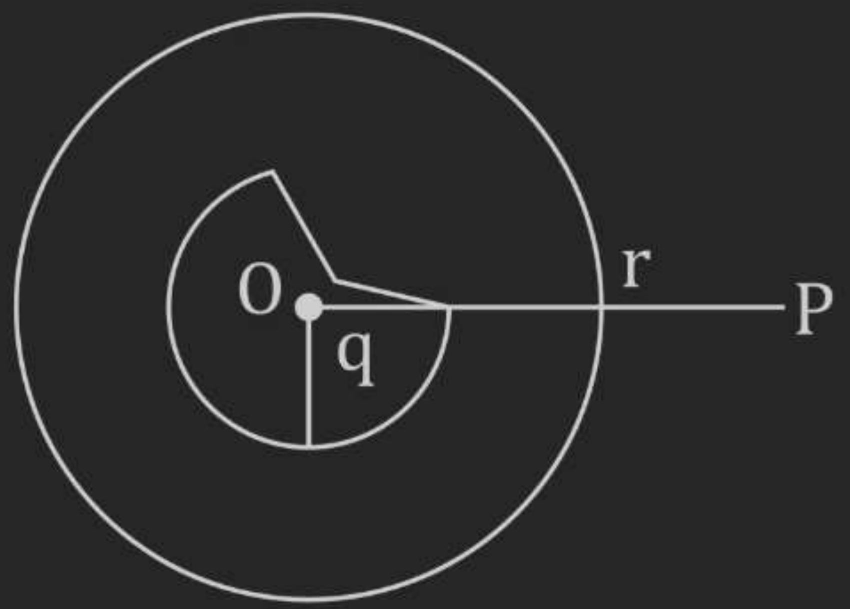
Conductor

H.W

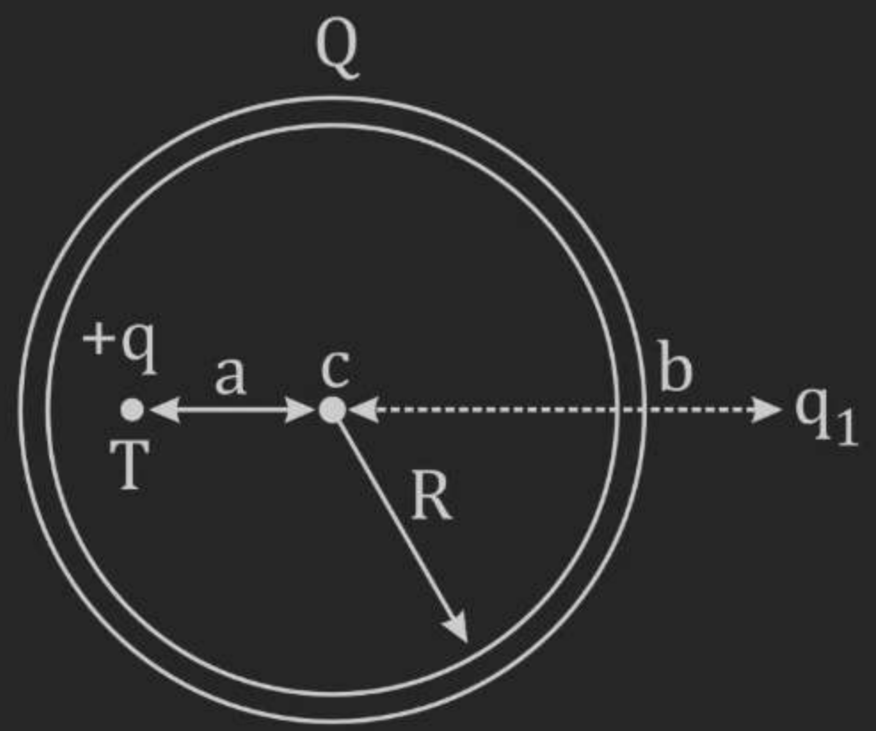
The point charge q is within an electrically neutral conducting shell whose outer surface has spherical shape. Find the potential V at a point P lying outside the shell at a distance r from the centre O of the outer sphere.



H.W

Conductor

A thin metallic spherical shell contains a charge Q over it. A point charge +q is placed inside the shell at point T separated from the centre by distance " a ". Another point charge q_1 is placed outside the shell at a distance b from the centre as shown in the adjacent Fig. Now select the correct statement(s) from the following.



(a) Electric field at the centre due to charge over outer surface of the shell is zero.

(b) Electric field at the centre due to charge over outer surface of the shell is $\frac{q_1}{4\pi\varepsilon_0 b^2}$.

(c) Electric potential at the centre due to all charges in space is $\frac{1}{4\pi\varepsilon_0}\left[\frac{q}{a}-\frac{q}{R}+\frac{Q}{R}+\frac{q_1}{b}\right]$.

(d) Electric potential at the centre due to all charges in space is $\frac{1}{4\pi\varepsilon_0}\left[\frac{q}{a}+\frac{Q}{R}+\frac{q_1}{b}\right]$.

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HW.

Conductor

There are 4 concentric shells A, B, C and D of radius a, 2 a, 3 a, 4 a respectively. Shells B and D are given charges +9 and -9 respectively. Shell C is now earthed. Find the potential difference $V_A - V_C$.