DPP – 8 (Electrostatics)

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Q 1. A point charge Q is placed at the centre of a hollow spherical neutral conductor of inner radius R_1 and outer radius R_2. Then

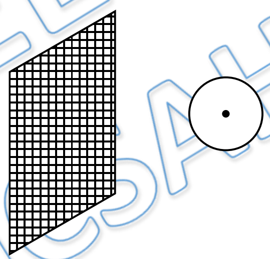
(a) Potential of the inner surface of the conductor is $\frac{KQ}{R_2}$

(b) Potential of the outer surface of the conductor is $\frac{KQ}{R_2}$

(c) Potential difference between inner and outer surface is KQ $\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

(d) Potential of inner surface of the conductor is $\frac{KQ}{R_2-R_1}$

Q 2. Let there be a non conducting infinite large sheet of charge of surface charge density $\frac{1}{36\pi}nC/m^2$. An uncharged conducting spherical shell of radius 20 cm is placed in front of sheet. A point charge 6mC is placed at centre of the shell. Force on point charge due to shell is x mN. Find value of x.



(a) 2 (b) 3 (c) 6 (d) 8

Q 3. A point charge q is placed inside a conducting spherical shell of inner radius 2R and outer radius 3R at a distance of R from the centre of the shell. The electric potential at the centre of shell will be $\frac{1}{4\pi\varepsilon_0}$ times

(a) $\frac{q}{2R}$ (b) $\frac{4q}{3R}$ (c) $\frac{5q}{6R}$ (d) $\frac{2q}{3R}$

Q 4. A point charge q is placed at a distance of r from the centre of an uncharged conducting spherical shell of radius R (<r). The potential at any point on the sphere is:

(a) zero (b) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$ (c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{qR}{r^2}$ (d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{qr^2}{R}$

Q 5. A point charge q is placed at a distance r from the centre O of an uncharged spherical shell of inner radius R and outer radius 2R. The distance r <R. The electric potential at the centre of the shell will be

(a) $\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r}-\frac{1}{2R}\right)$ (b) $\frac{q}{4\pi\varepsilon_0 r}$

(c) $\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r}+\frac{1}{2R}\right)$ (d) None of these

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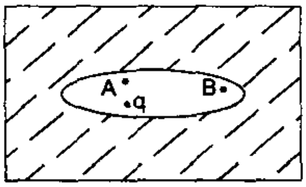
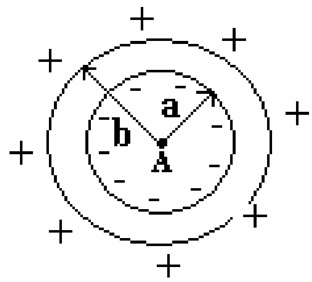
Q 6. An elliptical cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then: ε_0



(a) electric field near A in the cavity = electric field near B in the cavity
(b) charge density at A = charge density at B
(c) potential at A = potential at B
(d) electric field near A in the cavity > electric field near B in the cavity

Comprehension (Q.7 to Q.8)

An empty thick conducting shell of inner radius a and outer radius b is shown in figure. If it is observed that after putting a charge at A the inner face of the shell carries a uniform charge density $'-\sigma'$ and the surface carries a uniform charge density $'\sigma'$



Q 7. If another point charge q_B is also placed at a distance c (>b) from the center of shell, then choose the correct statements

(a) force experienced by charge A is $\frac{\sigma q_A b^2}{\varepsilon_0 c^2}$

(b) force experienced by charge A is zero

(c) The force experienced by charges B is $\frac{\sigma q_B b^2}{\varepsilon_0 c^2}$

(d) The force experienced by charge B is $\frac{k q_A q_B}{c^2}$

Q 8. If the charge q_A is slowly moved inside the shell, then choose the statement(s)
(a) Charge distribution on the inner and outer face of the shell changes
(b) Charge distribution on the inner face of the shell changes only.
(c) The force acting on the charge B charges
(d) The charge B also starts moving slowly

Q 9. In the shown figure the conductor is uncharged and a charge q is placed inside a spherical cavity at a distance a from its centre (C). Point P and charge +Q are as shown. a, b, c, d are known.

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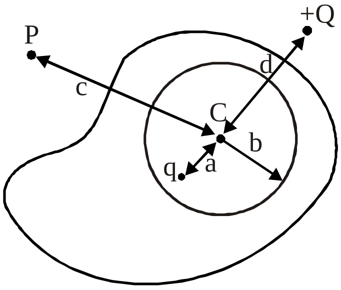


	Column-I	Column-II
(A)	Electric field due to induced charges on the inner surface of cavity at point P	(P) zero
(B)	Electric potential due to charges on the inner surface of cavity and q at P	(Q) non-zero
(C)	Electric field due to induced charges on the outer surface of conductor and Q at C	(R) value can be stated with the given data.
(D)	Electric potential due to induced charges on the inner surface of cavity at C	(S) value cannot be stated from the given data

Q 10. There is a small hole at the surface of uniformly charged long cylindrical shell of surface charge density σ. Electric field at centre of hole is

(a) $\frac{\sigma}{8\epsilon_0}$ (b) $\frac{\sigma}{4\epsilon_0}$ (c) $\frac{\sigma}{2\epsilon_0}$ (d) $\frac{\sigma}{\epsilon_0}$

Q 11. Electrostatic pressure at Point A of conductor sphere is $\frac{\sigma^2}{2\epsilon_0}$, where σ is surface charge density at A. Now a point charge Q is placed at B due to which surface charge density at A changes to σ_1. New clectostatic pressure at A is

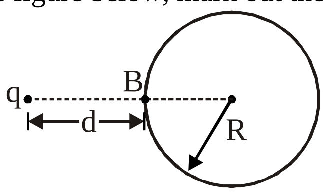
(a) $\frac{\sigma_1^2}{2\epsilon_0}$ - $\frac{Q\sigma_1}{4\pi\epsilon_0 r^2}$

(b) $\frac{\sigma_1^2}{2\epsilon_0}$ + $\frac{Q\sigma_1}{4\pi\epsilon_0 r^2}$

(c) $\frac{\sigma_1^2}{2\epsilon_0}$

(d) $\frac{\sigma^2}{2\epsilon_0}$

Q 12. For the situation shown in the figure below, mark out the correct statement(s)



Hollow neutral conductor

(a) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0(d+R)}$

(b) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0 d}$

(c) Potential of the conductor can't be determined as nature of distribution of induced charges is not known

(d) Potential at point B due to induced charges is $\frac{-qR}{4\pi\varepsilon_0(d+R)d}$

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Answer Key

Q.1 a,b	Q.2 b	Q.3 c	Q.4 b	Q.5 a
Q.6 c,d	Q.7 b	Q.8 b	Q.10 c	Q.11 c
Q.12 a, d				

Q.9 (A)→QS; (B)→PR; (C)→PR; (D)→QR

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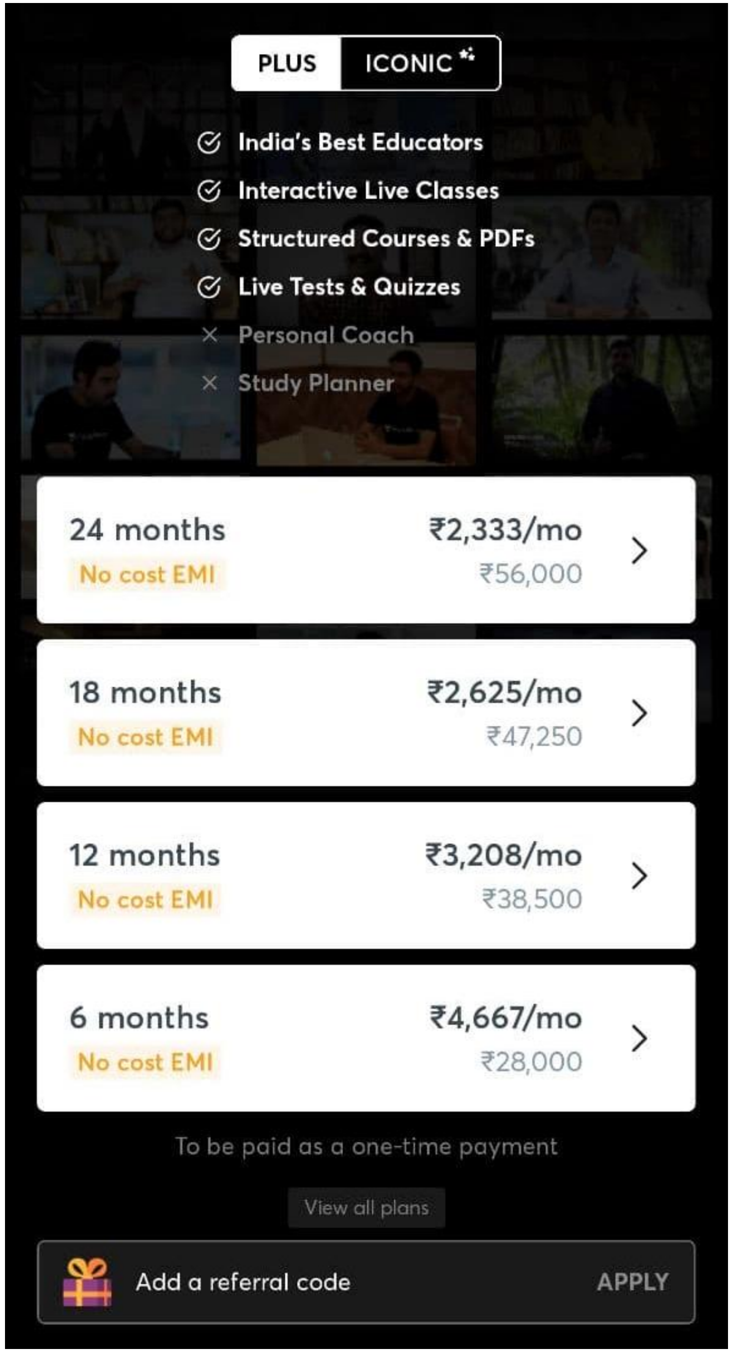

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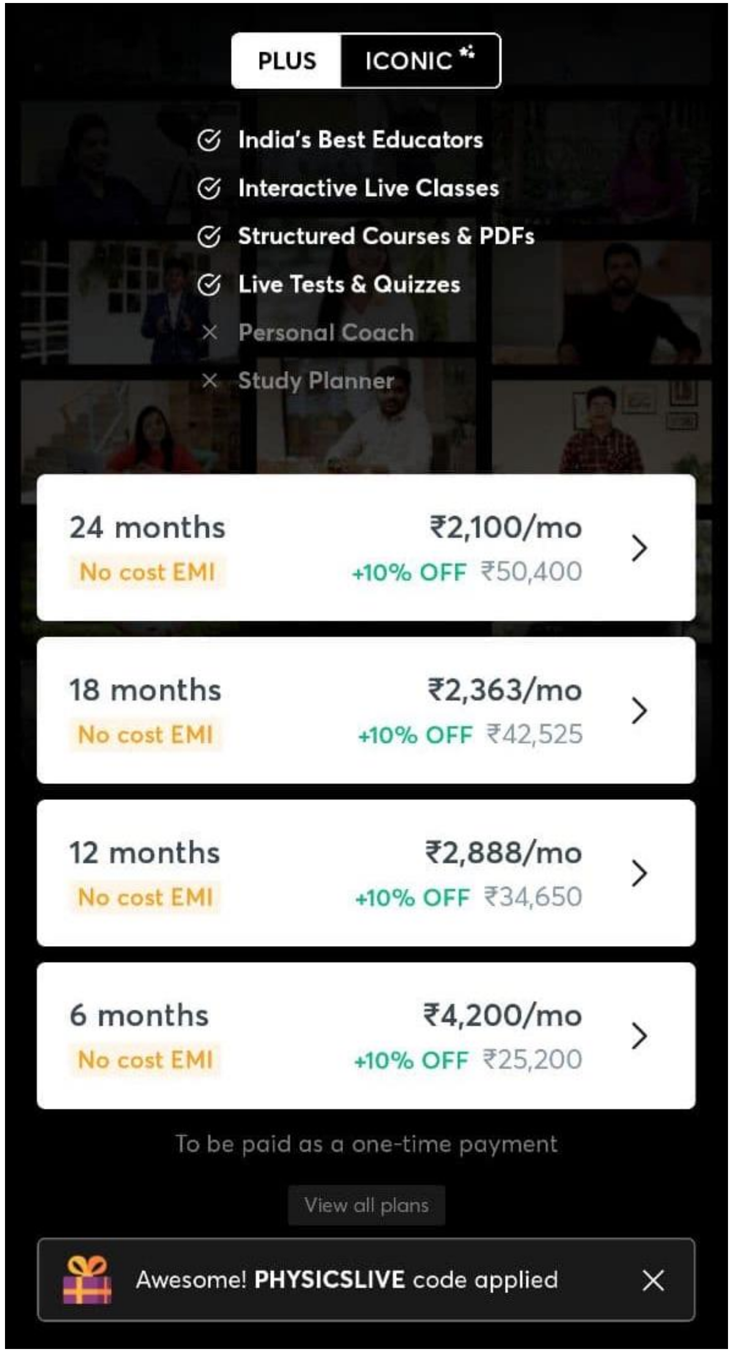

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Written Solution

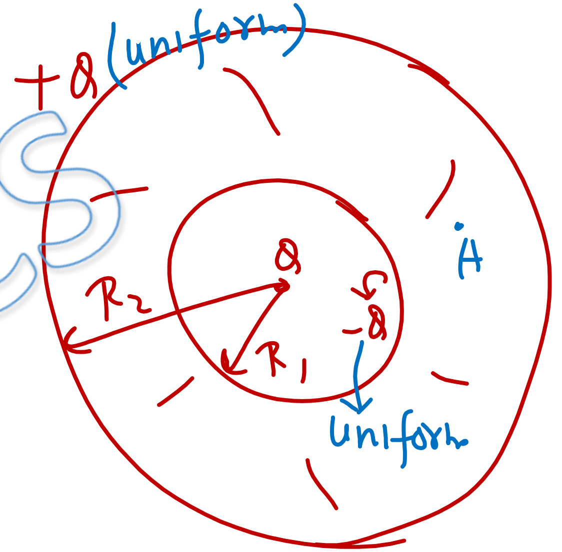
DPP- 8 Electrostatics : Cavity in Conductor, Field near Conductor Surface, Electrostatic Pressure

By Physicsaholics Team

Q1) A point charge Q is placed at the centre of a hollow spherical neutral conductor of inner radius R_1 and outer radius R_2. Then

Potential of Conductor = V_A = V_A due to inner charges + " " outer "

$= 0 + \frac{KQ}{R_2}$



(a) Potential of the inner surface of the conductor is $\frac{KQ}{R_2}$

(b) Potential of the outer surface of the conductor is $\frac{KQ}{R_2}$

(c) Potential difference between inner and outer surface is KQ $\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

(d) Potential of inner surface of the conductor is $\frac{KQ}{R_2 - R_1}$

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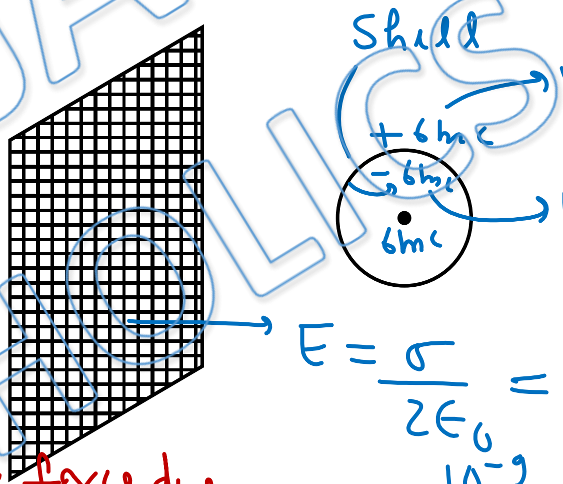
Q2) Let there be a non conducting infinite large sheet of charge of surface charge density $\frac{1}{36\pi} nC/m^2$. An uncharged conducting spherical shell of radius 20 cm is placed in front of sheet. A point charge 6mC is placed at centre of the shell. Force on point charge due to shell is x mN. Find value of x.

Net force on charge at centre

= force by inner charges (−6mc)

= 0



$E = \frac{\sigma}{2\epsilon_0} = \frac{1\times10^{-9}}{36\pi\times2\epsilon_0}$

$= \frac{10^{-9}}{18\times4\pi\epsilon_0} = \frac{9\times10^{9}\times10^{-9}}{18}$

$E = .5\ N/C$

Net force on central charge = force due to sheet + force due to shell

(a) 2 (b) 3 (c) 6 (d) 8

$0 = 6m(.5) +$ force due to shell

force due to shell $= -3\ mN$

$= 3mN \leftarrow$

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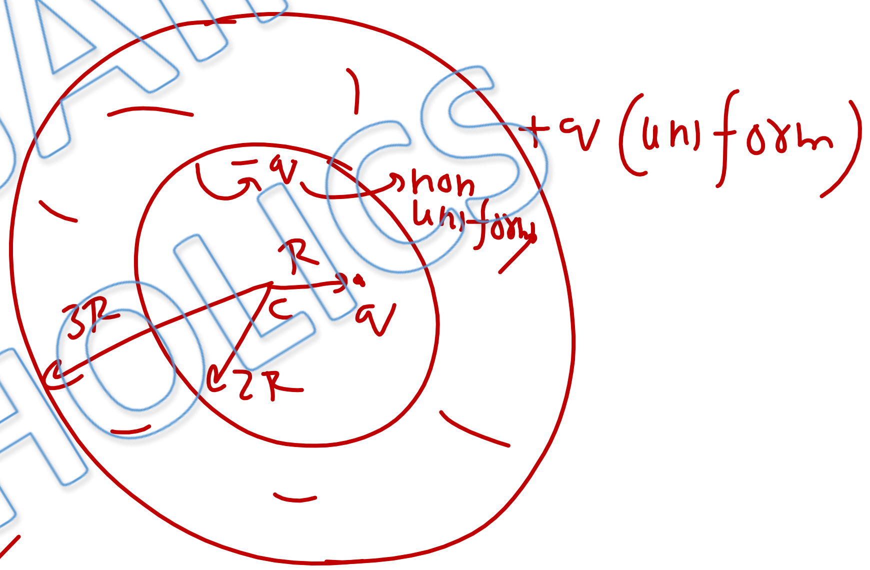
Q3) A point charge q is placed inside a conducting spherical shell of inner radius 2R and outer radius 3R at a distance of R from the centre of the shell. The electric potential at the centre of shell will be $\frac{1}{4\pi\varepsilon_0}$ times

$$V_c = \frac{Kq}{R} - \frac{Kq}{2R} + \frac{Kq}{3R}$$

$$= \frac{6 - 3 + 2}{6}\,\frac{Kq}{R}$$

$$= \frac{5}{6}\,\frac{Kq}{R}$$



(a) $\frac{q}{2R}$ (b) $\frac{4q}{3R}$ (c) $\frac{5q}{6R}$ (d) $\frac{2q}{3R}$

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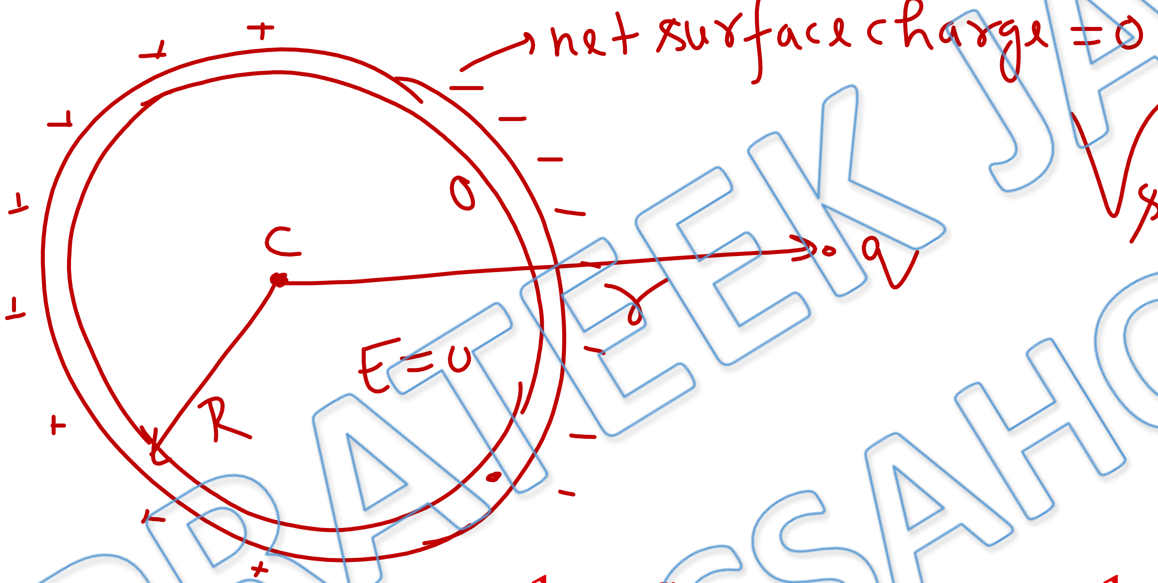
Q4) A point charge q is placed at a distance of r from the centre of an uncharged conducting spherical shell of radius R (<r). The potential at any point on the sphere is:



$V_{sphere} = V_c$

$= V_c$ due to q + V_c due to surface

$= \frac{Kq}{r} + 0$

(a) zero (b) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$ (c) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{qR}{r^2}$ (d) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{qr^2}{R}$

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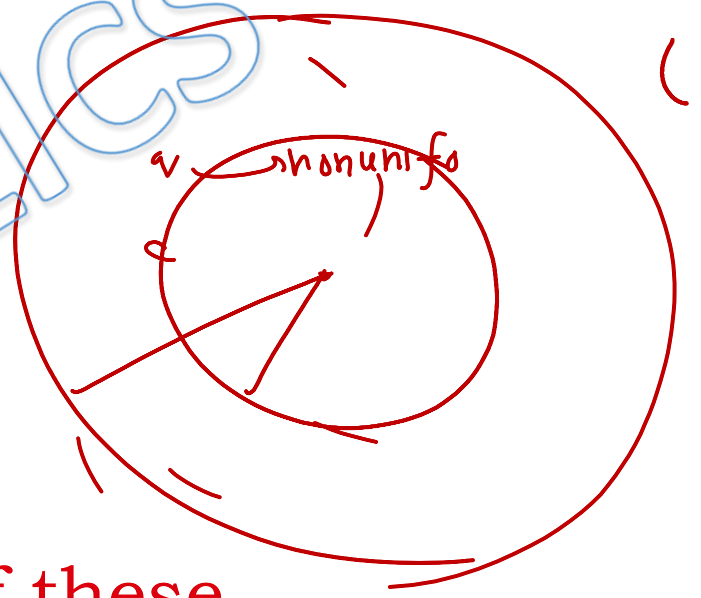
Q5) A point charge q is placed at a distance r from the centre O of a uncharged spherical shell of inner radius R and outer radius 2R. The distance r <R. The electric potential at the centre of the shell will be



(a) $\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r}-\frac{1}{2R}\right)$

(b) $\frac{q}{4\pi\varepsilon_0 r}$

(c) $\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r}+\frac{1}{2R}\right)$

(d) None of these

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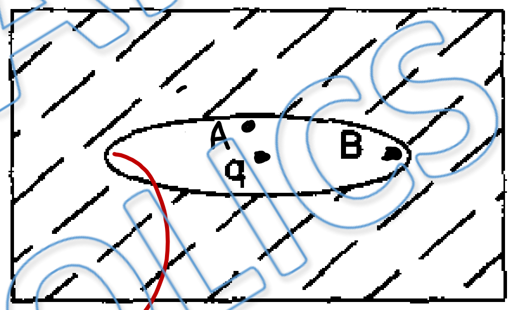
Q6) An elliptical cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then: ε_0

$|\sigma_A| > |\sigma_B|$

$\Rightarrow \quad E_A > E_B$



$-\sigma$ (non uniform)

(a) electric field near A in the cavity = electric field near B in the cavity

(b) charge density at A = charge density at B

(c) potential at A = potential at B $\Rightarrow$ V of all points of conductor have equal value

(d) electric field near A in the cavity > electric field near B in the cavity

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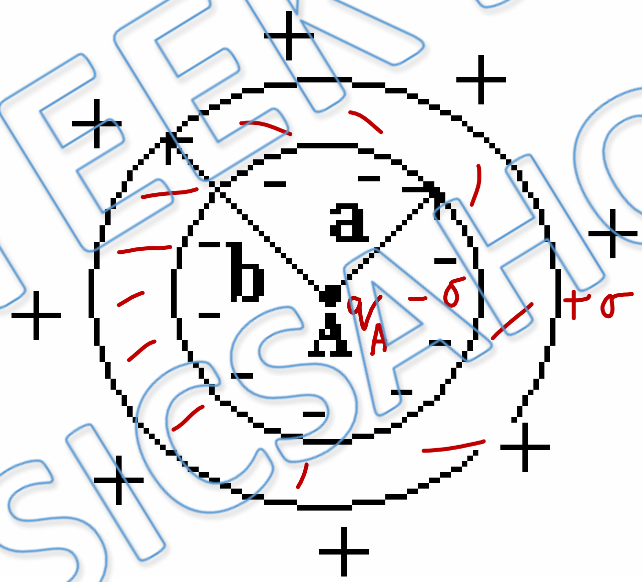
Comprehension: Q7 to Q8

An empty thick conducting shell of inner radius a and outer radius b is shown in figure. If it is observed that after putting a charge at A the inner face of the shell carries a uniform charge density $'-\sigma'$ and the surface carries a uniform charge density $'\sigma'$



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Q7) If another point charge q_B is also placed at a distance c (>b) from the center of shell, then choose the correct statements

$-\sigma = -\frac{q_A}{4\pi a^2}$

force on B = force due to inner charges + force due to $\sigma \cdot 4\pi b^2$

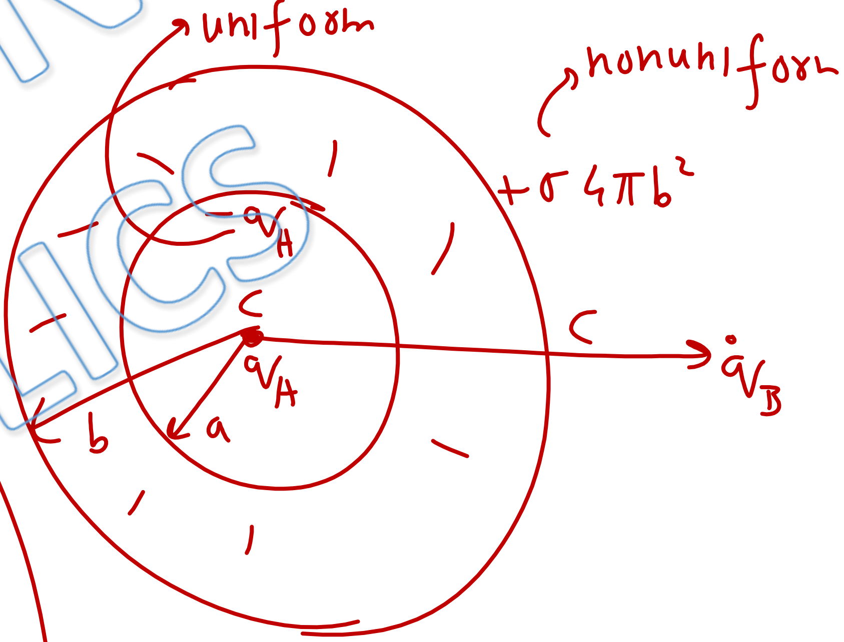
$= 0 +$ force due to $\sigma \cdot 4\pi b^2$

(a) force experienced by charge A is $\frac{\sigma q_A b^2}{\varepsilon_0 c^2}$

(b) force experienced by charge A is zero

(c) The force experienced by charges B is $\frac{\sigma q_B b^2}{\varepsilon_0 c^2}$

(d) The force experienced by charge B is $\frac{k q_A q_B}{c^2}$



we can not find this force since charge is non uniform

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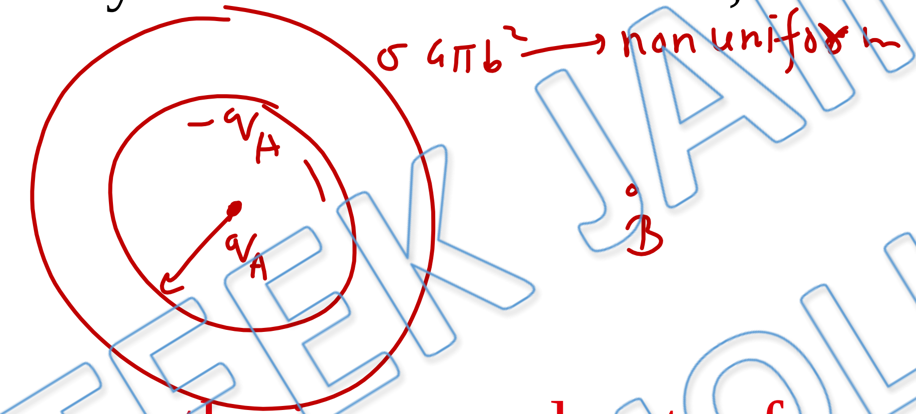
Q8) If the charge q_A is slowly moved inside the shell, then choose the statement(s)



(a) Charge distribution on the inner and outer face of the shell changes

(b) Charge distribution on the inner face of the shell changes only.

(c) The force acting on the charge B changes

(d) The charge B also starts moving slowly

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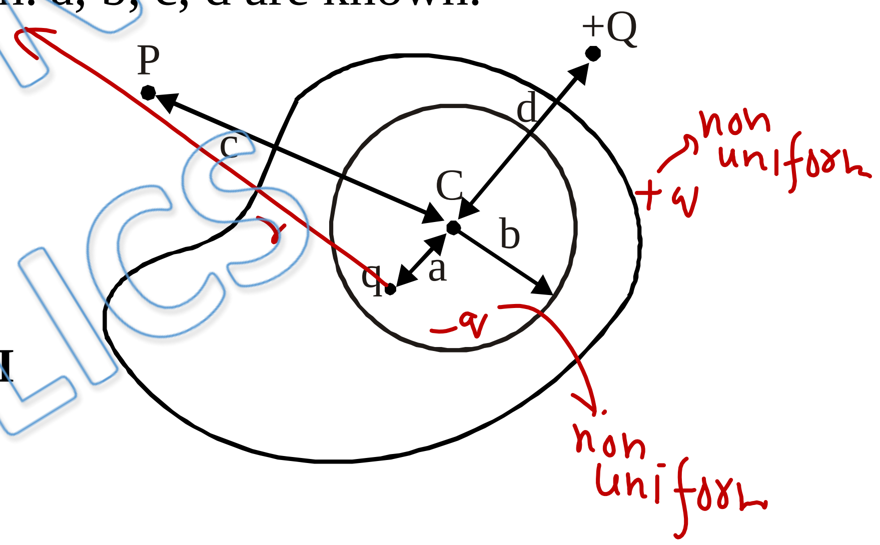
Q9) In the shown figure the conductor is uncharged and a charge q is placed inside a spherical cavity at a distance a from its centre (C). Point P and charge +Q are as shown. a, b, c, d are known.



Column-I		Column-II
(A)	Electric field due to induced charges on the inner surface of cavity at point P	(P) zero
(B)	Electric potential due to charges on the inner surface of cavity and q at P	(Q) non-zero
(C)	Electric field due to induced charges on the outer surface of conductor and Q at C	(R) value can be stated with the given data.
(D)	Electric potential due to induced charges on the inner surface of cavity at C	(S) value cannot be stated from the given data

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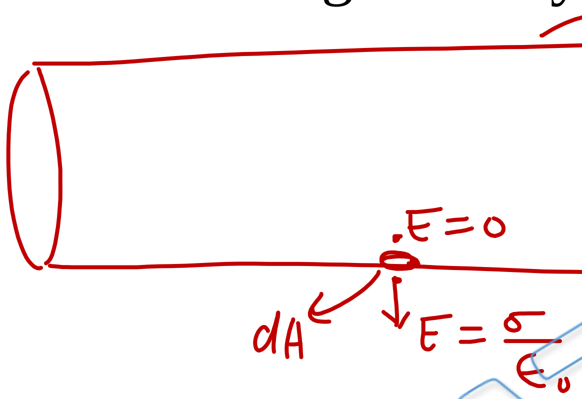
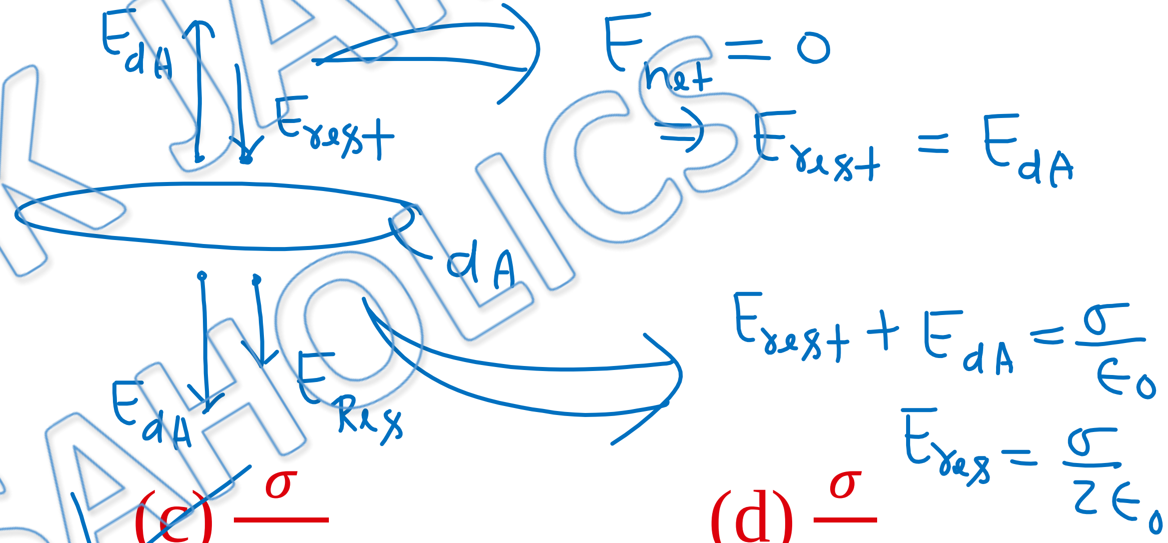
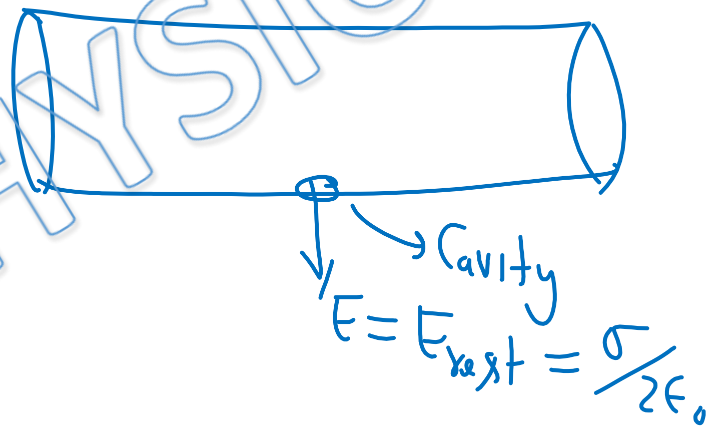
Q10) There is a small hole at the surface of uniformly charged long cylindrical shell of surface charge density σ. Electric field at centre of hole is





(a) $\frac{\sigma}{8\epsilon_0}$ (b) $\frac{\sigma}{4\epsilon_0}$ (c) $\frac{\sigma}{2\epsilon_0}$ (d) $\frac{\sigma}{\epsilon_0}$



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Q11) Electrostatic pressure at Point A of conductor sphere is $\frac{\sigma^2}{2\epsilon_0}$, where σ is surface charge density at A. Now a point charge Q is placed at B due to which surface charge density at A changes to σ_1. New electostatic pressure at A is

(a) $\frac{\sigma_1^2}{2\epsilon_0} - \frac{Q\sigma_1}{4\pi\epsilon_0 r^2}$

(b) $\frac{\sigma_1^2}{2\epsilon_0} + \frac{Q\sigma_1}{4\pi\epsilon_0 r^2}$

(c) $\frac{\sigma_1^2}{2\epsilon_0}$ ✓

(d) $\frac{\sigma^2}{2\epsilon_0}$

rest → rest part of surface + Q

$E_{dA} - E_{rest} = 0$

$E_{rest} = E_{dA}$

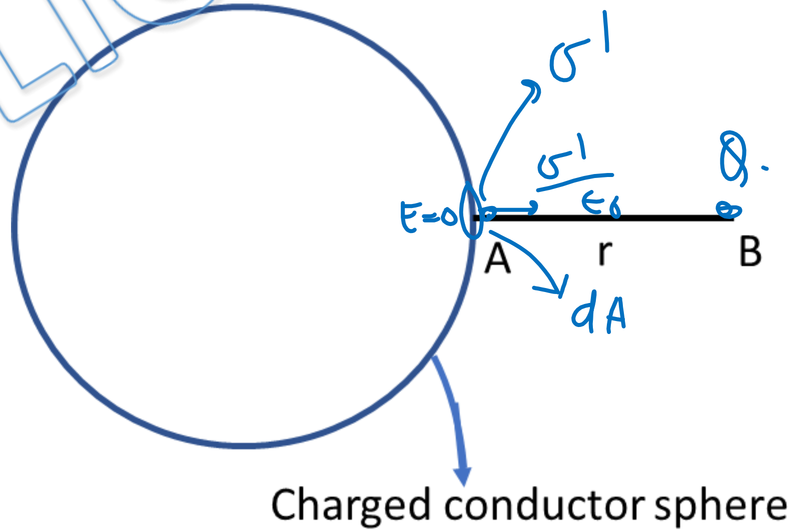
$E_{res} + E_{dA} = \frac{\sigma'}{\epsilon_0}$

$\Rightarrow E_{res} = \frac{\sigma'}{2\epsilon_0}$

Charge on dA $= \sigma' dA$

force on dA, $dF = \frac{\sigma'^2}{2\epsilon_0} dA$

$P = \frac{\sigma'^2}{2\epsilon_0}$



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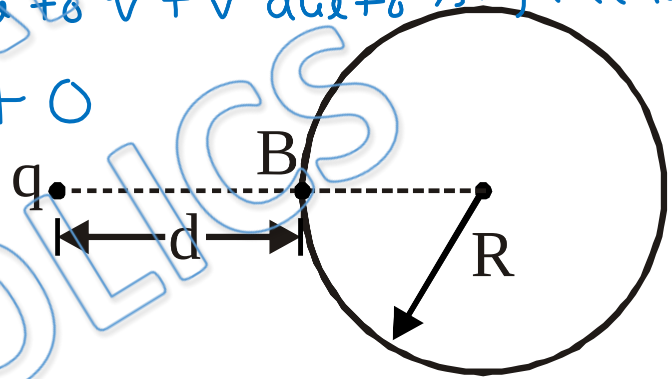
Q12) For the situation shown in the figure below, mark out the correct statement(s)



Hollow neutral conductor

(a) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0(d+R)}$

(b) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0 d}$

(c) Potential of the conductor can't be determined as nature of distribution of induced charges is not known

(d) Potential at point B due to induced charges is $\frac{-qR}{4\pi\varepsilon_0(d+R)d}$

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net induced charge = 0

$V_A = V_C = V$ due to q + V due to surface charge $= \frac{kq}{d+R} + 0$

$V_B = V_C = \frac{q}{4\pi\epsilon_0(d+R)}$

V_B due to q + V_B due to induced $= \frac{q}{4\pi\epsilon_0(d+R)}$

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