PARISHRAM

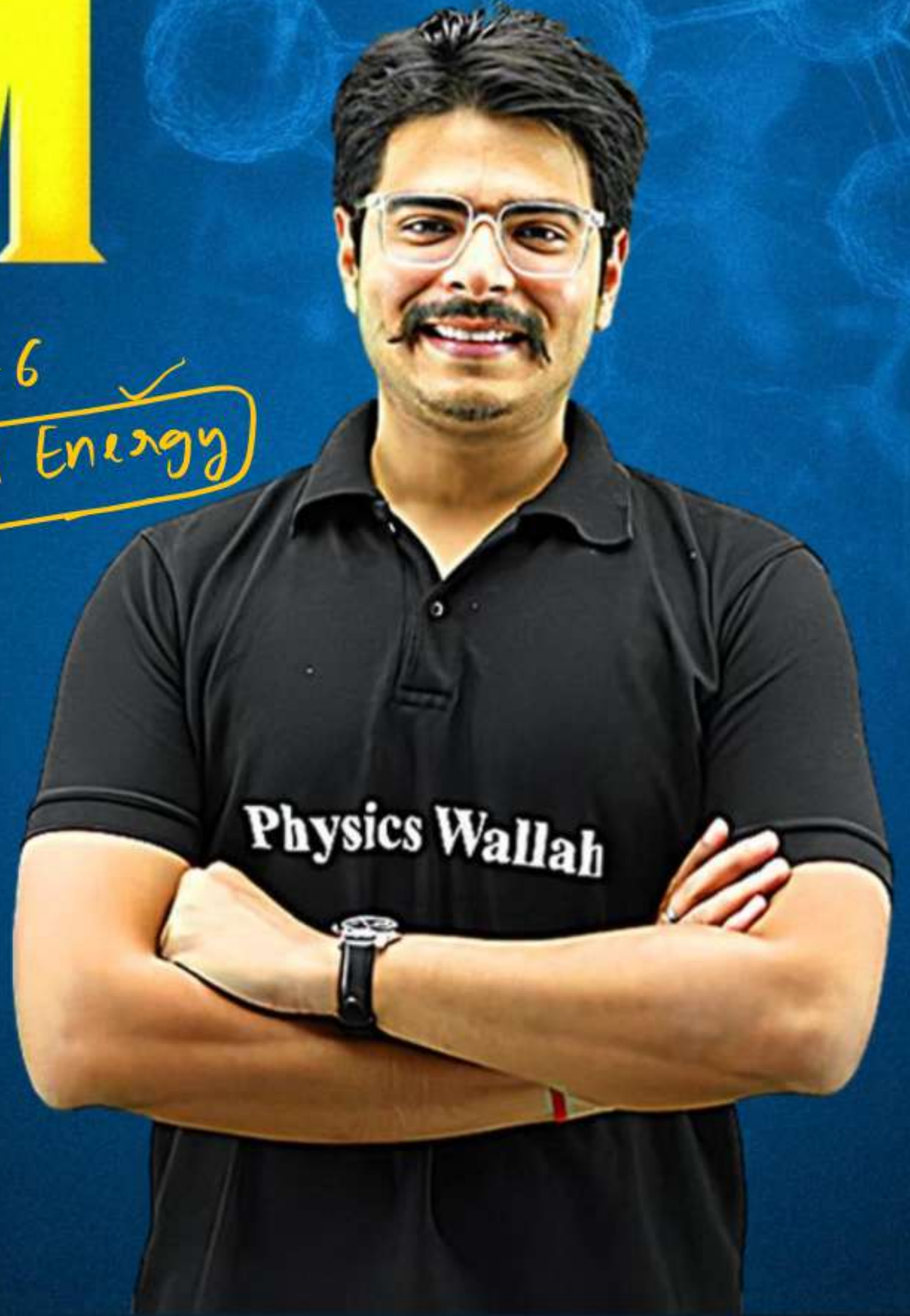
2026

Ch-6
Work and Energy

Electrostatic Potential and Capacitance

PHYSICS | Lecture - 1

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Work - Energy ki YKB
- **B** Electrostatic Potential Energy
- **C**
- **D**
- **E**

Unit I: **Electrostatics**

Chapter–1: Electric Charges and Fields

Electric charges, Conservation of charge, Coulomb's law-force between two- point charges, forces between multiple charges; superposition principle and continuous charge distribution.

Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field.

Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

Chapter–2: Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field.

Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarization, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor (no derivation, formulae only).

Concepts Related to Work Energy

$Cf \rightarrow$ 1. Gravitational
2. Spring/Elastic
3. Electrostatic (coulomb)

1. Work-Energy Theorem

$$\boxed{W_{all} = \Delta K}$$

$$W_{cf} + W_{ncf} = \Delta K$$

$$W_{elec} + W_{ext} = \Delta K$$

$$-\Delta U + W_{ext} = \Delta K$$

$$* \boxed{W_{ext} = \Delta K + \Delta U}$$

Constant Velocity
or
Slowly
or
Zero acceleration
$(\Delta K = 0)$

$$* \boxed{W_{ext} = \Delta U}$$

2. Workdone by Conservative force

$$\boxed{W_{cf} = -\Delta U}$$

$$W_{elec} = -\Delta U$$

Electrostatic Potential Energy

(U_e) $\quad m_1 \overset{r}{\longleftrightarrow} m_2$

$U_g = -\frac{G m_1 m_2}{r}$

The work done in bringing a test charge from infinity to a given point in the electrostatic field of another charge slowly is stored in the form of electrostatic potential energy.

$+q_1 \overset{r}{\longleftrightarrow} +q_2$

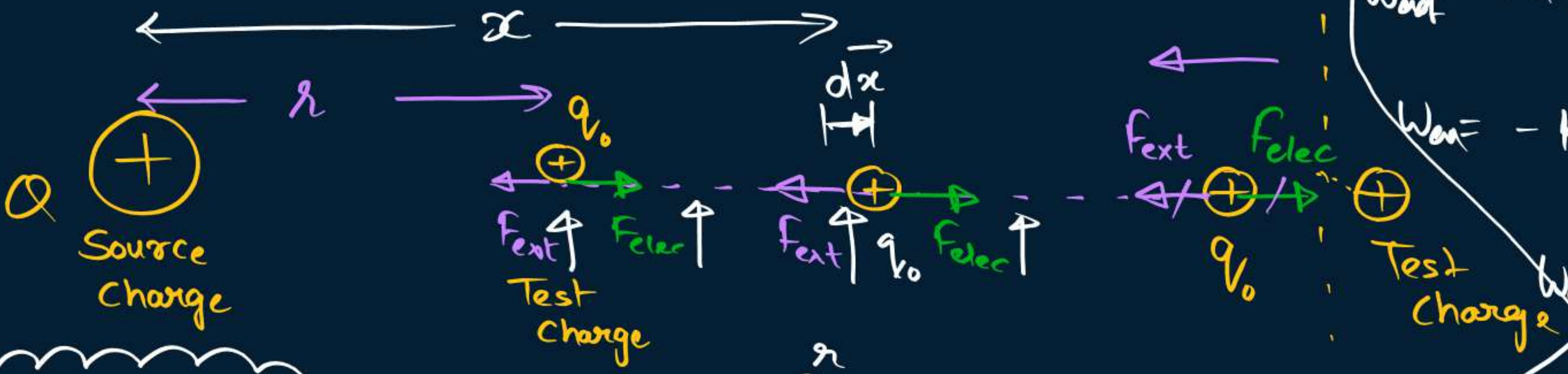
$$\boxed{U = \frac{k q_1 q_2}{r}}$$

SI unit = Joule (J)

Units – $\boxed{1 \text{ e.V.} = 1.6 \times 10^{-19} \text{ J}}$

(1 electron-volt)

Derivation



$$\boxed{W_{ext} = \Delta U}$$

$$W_{ext} = \int \vec{F}_{ext} \cdot d\vec{x}$$

$$W_{ext} = \int_{\infty}^{r} F_{ext}\, dx \cos\theta$$

$$W_{ext} = \int_{\infty}^{r} |F_{ext}|\, dx \cos 180^\circ$$

$$W_{ext} = -\int_{\infty}^{r} |F_{elec}|\, dx$$

$$W_{ext} = -\int_{\infty}^{r} \frac{kQq_0}{x^2}\, dx$$

$$W_{ext} = -kQq_0 \int_{\infty}^{r} \frac{1}{x^2}\, dx$$

$$W_{ext} = -kQq_0 \int_{\infty}^{r} x^{-2}\, dx$$

$$W_{ext} = -kQq_0 \left[\frac{x^{-2+1}}{-2+1}\right]_{\infty}^{r}$$

$$W_{ext} = -kQq_0 \left[\frac{x^{-1}}{-1}\right]_{\infty}^{r}$$

$$W_{ext} = -kQq_0 \left[\frac{-1}{x}\right]_{\infty}^{r}$$

$$W_{ext} = kQq_0 \left[\frac{1}{x}\right]_{\infty}^{r}$$

$$W_{ext} = kQq_0 \left[\frac{1}{r} - \cancel{\frac{1}{\infty}}^{\,0}\right]$$

$$W_{ext} = \frac{kQq_0}{r}$$

$$\boxed{\Delta U = \frac{kQq_0}{r}}$$

$$\Delta U = \frac{kQq_0}{r}$$

$$U_f - U_i = \frac{kQq_0}{r}$$

let $r \rightarrow \infty$, $U_i = 0$

$$U_f - 0 = \frac{kQq_0}{r}$$

$$U_f = \frac{kQq_0}{r}$$

$$\boxed{U = \frac{kQq_0}{r}}$$

$$U = \frac{kQq_0}{r}$$

Generally

$$\boxed{U = \frac{kq_1 q_2}{r}}$$

* → याद

Some important points about potential energy

ΔU ✓ U ×

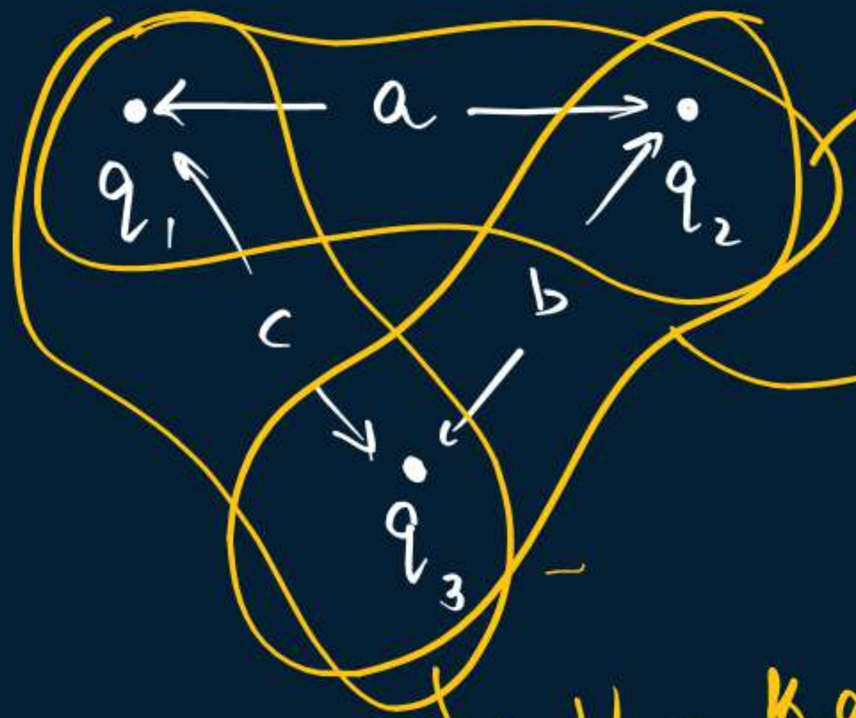
- $\boxed{\text{Always potential energy change is defined.}}$ If we assume potential energy to be zero at one point, then we can find potential energy at other point w.r.t. that zero reference.

- Electrostatic potential energy is defined for a system of charges, minimum two charges are required.

$$q_1 \longleftarrow r \longrightarrow q_2$$

$$V = \frac{kq_1q_2}{r}$$

Potential Energy of system containing more than two charges



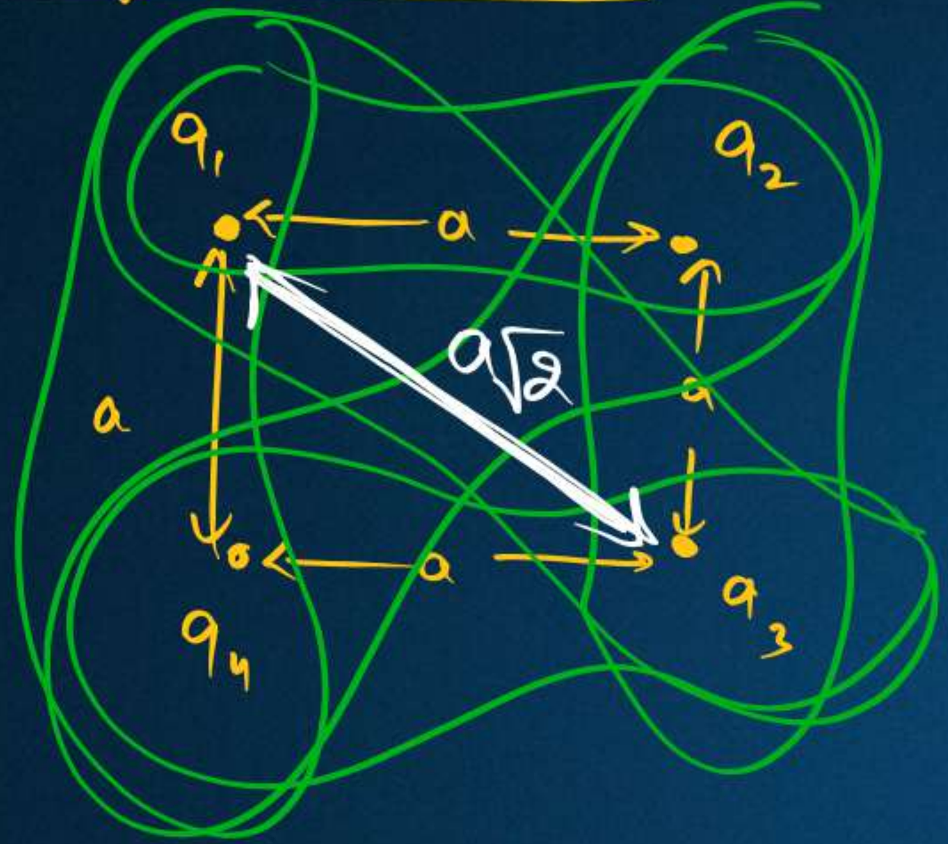
$$U_1 = \frac{Kq_1q_2}{a}$$

$$U_3 = \frac{Kq_2q_3}{b}$$

$$U_2 = \frac{Kq_1q_3}{c}$$

$$U_{net}^{sys} = U_1 + U_2 + U_3$$

System of four charges → 6 terms (6 Jodi)



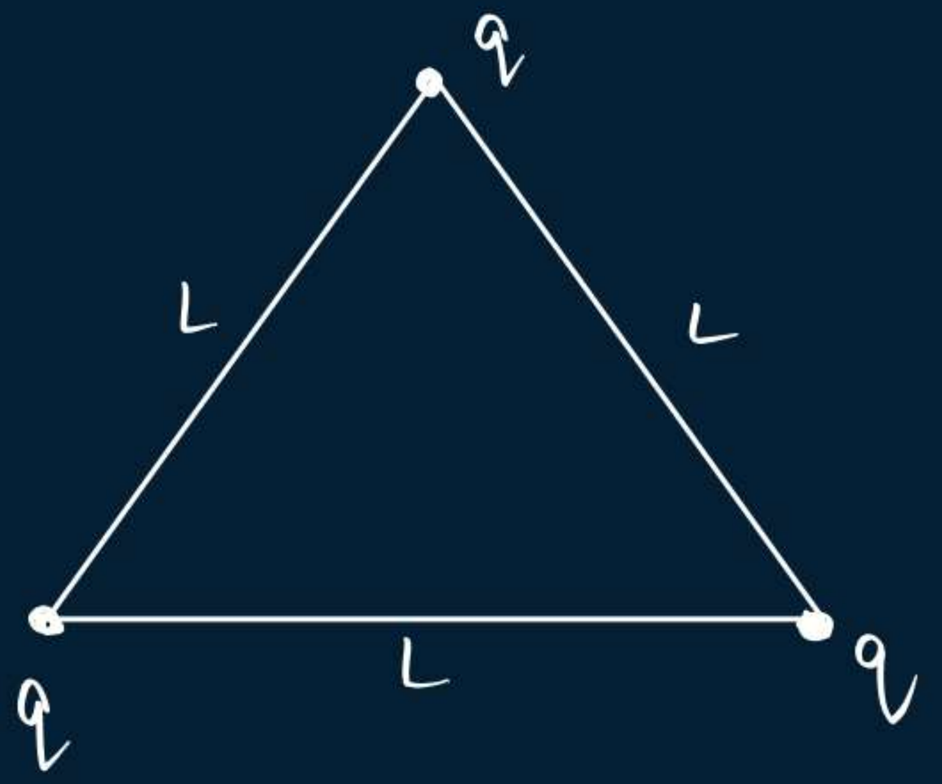
$$U_{net}^{sys} = U_1 + U_2 + U_3 + U_4 + U_5 + U_6$$

$$= \frac{kq_1q_2}{a} + \frac{kq_2q_3}{a} + \frac{kq_3q_4}{a} + \frac{kq_4q_1}{a} + \frac{kq_1q_3}{a\sqrt{2}} + \frac{kq_2q_4}{a\sqrt{2}}$$

QUESTION

H.W.

If three charges each of charge 'q' are placed at the vertices of equilateral triangle of side 'L'. Then the potential energy of system is:



$U_{net}^{sys} = ?$

RDx → Reasoning Sawaal ⟹ $\dfrac{n(n-1)}{2}$

4 chairs

$\dfrac{\overset{2}{\cancel{4}}(4-1)}{\cancel{2}}$

$2 \times 3 = 6$

↓

Jodi

$\boxed{\text{50 log}}$ → handshakes $= \dfrac{50(50-1)}{2} = \dfrac{\overset{25}{\cancel{50}} \times 49}{\cancel{2}} =$

Party

IPL has 10 teams

$\dfrac{10(10-1)}{2} = \dfrac{\overset{5}{\cancel{10}} \times 9}{\cancel{2}}$

= 45 Matches

$\dfrac{5(5-1)}{2}$

$5 \times \dfrac{\overset{2}{\cancel{4}}}{\cancel{2}}$

$= 10$

Homework

- Notes
- Work - Energy (UDAY 2025)
- Derivation × 3
- H.W.


PARISHRAM
2026
Electrostatic Potential
and Capacitance
PHYSICS
Lecture - 2
BY - RAKSHAK SIR
Physics Wallah

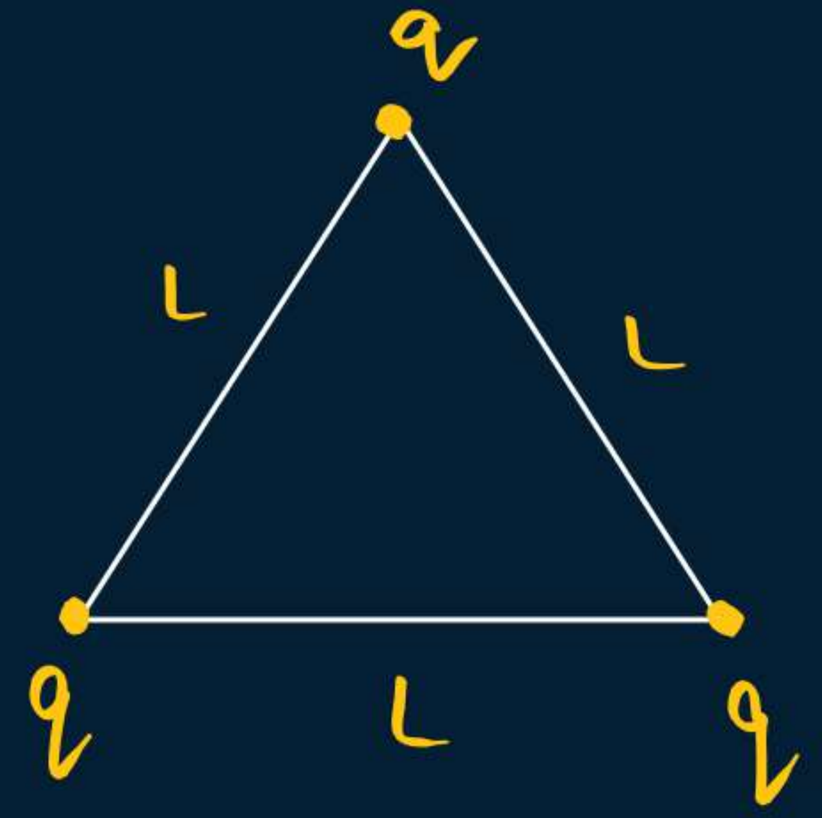
Topics *to be covered*

- **A** ELECTROSTATIC POTENTIAL ENERGY (PART - 2)
- **B** ELECTRIC POTENTIAL
- **C**
- **D**
- **E**

HW QUESTION

$$\boxed{U = \frac{kq_1q_2}{r}}$$

If three charges each of charge '*q*' are placed at the vertices of equilateral triangle of side '*L*'. Then the potential energy of system is:



$$U_{net}^{sys} = U_1 + U_2 + U_3$$

$$= \frac{kqq}{L} + \frac{kqq}{L} + \frac{kqq}{L}$$

$$= \frac{3kq^2}{L} \text{ Ans}$$

QUESTION

Three particles, each having a charge of 10μC are placed at the corners of an equilateral triangle of side 10 cm. The electrostatic potential energy of the system is:

A Zero

B Infinite

C 27 J

D 100 J

$$U_{net}^{sys} = \frac{3kq^2}{L}$$

$$= \frac{3 \times 9 \times 10^9 \times 10 \times 10^{-6} \times 10 \times 10^{-6}}{\frac{\cancel{10}}{10\cancel{0}}}$$

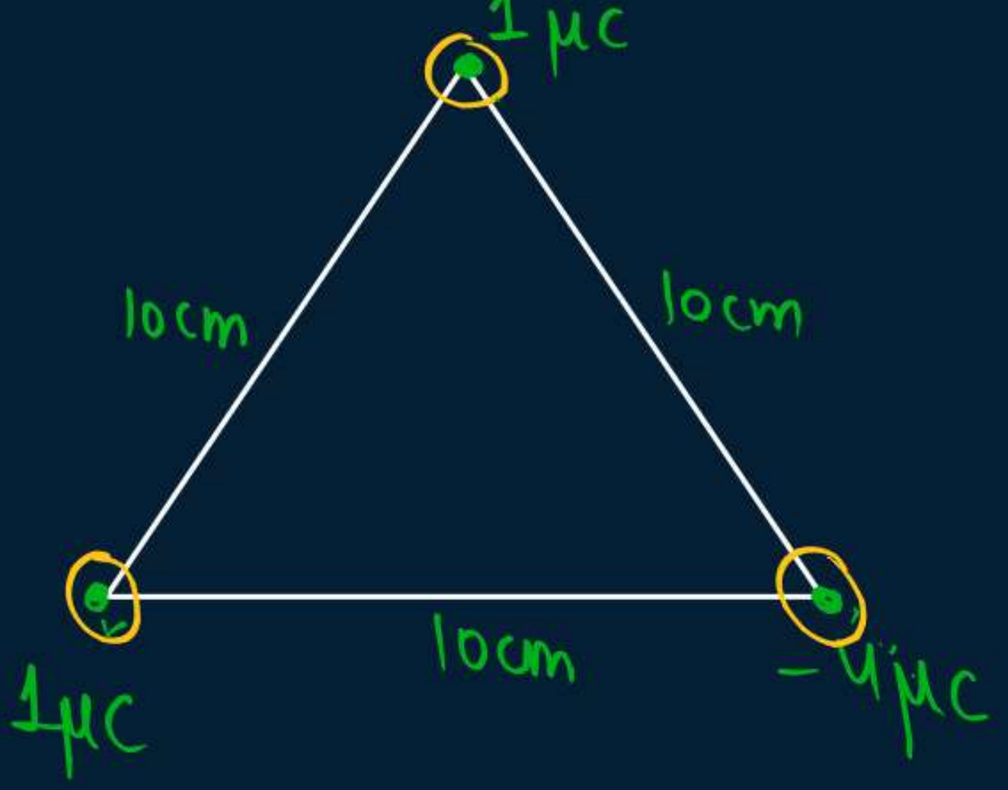
$$= \frac{27 \times \cancel{10^{12}} \times \cancel{10^{-12}}}{1} = 27\ J$$

QUESTION

$+0.63\,J$

Calculate the amount of work done to dissociate a system of three charges, two of 1 μC and one of –4 μC placed on the vertices of an equilateral triangle of side 10 cm.

[ALL India CBSE 2013]



$$U_{net}^{sys} = U_1 + U_2 + U_3$$

$$= \frac{k(+1)(-4)\times 10^{-12}}{\frac{10}{100}} + \frac{k(+1)(-4)\times 10^{-12}}{\frac{10}{100}} + \frac{k(+1)(+1)\times 10^{-12}}{\frac{10}{100}}$$

$$= \frac{k\times 10^{-12}}{\frac{10}{100}}\left[-4-4+1\right] = 9\times 10^{9}\times 10\times 10^{-12}\times -7$$

$$= -63\times 10^{-2}$$

$$U_{net}^{sys} = -0.63\,J$$

QUESTION

$*$ JEE

"Retry"

$\frac{Q}{q} = ?$

Three charges $-q$, Q and $-q$ are placed respectively at equal distances on a straight line. If the potential energy of the three charges is zero then what is the value of $Q : q$

(A) 1 : 1

(B) 1 : 2

(C) 1 : 3

(D) 1 : 4

$$0 = \frac{kq}{x}\left[-2Q + \frac{q}{2}\right]$$

$$0 = -2Q + \frac{q}{2}$$

$$2Q = \frac{q}{2}$$

$$\frac{Q}{q} = \frac{1}{4} \rightarrow 1:4$$

$$U_{net}^{sys} = U_1 + U_2 + U_3$$

$$= \frac{K\,-qQ}{x} + \frac{k(-q)Q}{x} + \frac{k(-q)(-q)}{2x}$$

$$U_{net} = -\frac{KqQ}{x} - \frac{KqQ}{x} + \frac{Kqq}{2x}$$

$$0 = \frac{kq}{x}\left[-Q - Q + \frac{q}{2}\right]$$

Important Concept related to P E

→ "Conceptual Questions"

eg ①

$\xleftarrow{\quad r \quad}\!\!\xrightarrow{}$

$+q_1$ Repulsion $+q_2$

$U = \dfrac{Kq_1q_2}{r}$

$U > 0$

$U +$

②

$\longleftarrow r \longrightarrow$

$-q_1$ $-q_2$

$U = \dfrac{k(-q_1)(-q_2)}{r}$

$U > 0$

$U +$

③

$\longleftarrow r \longrightarrow$

$+q_1$ $-q_2$

Attract

$U = \dfrac{k(q_1)(-q_2)}{r}$

$U < 0$

$U -$

* PE ka Sign − Dikhega !!
  - → Stability high
  - → PE is less
    (Kalesh kam hai)

* PE ka Sign + Dikhega !!
  - → Stability low
  - → PE is high
    (Kalesh Jyada hai)

ex -

$U_1 = 5\,J$

$U_2 = 7\,J$

Ex2 -

$U_1 = -3\,J$

$U_2 = -8\,J$

* RDx

Unstablity increose →

−8J −3J 0 +5J +7J

← Stability increase

Ex 1

Unstabity ↑

Stability ↑

Ex 2

Ex 3

Stability ↑

Stability ↑

Unstabity ↑

QUESTION

NEET

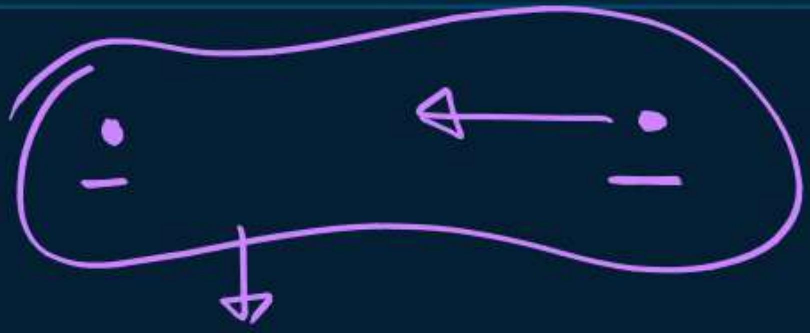
When one electron is taken towards the other electron, then the electric potential energy of the system:

A Decrease

B Increase

C Remain Unchanged

D IYKYK



Repulsion ↑

Unstable ↑

PE ↑

QUESTION

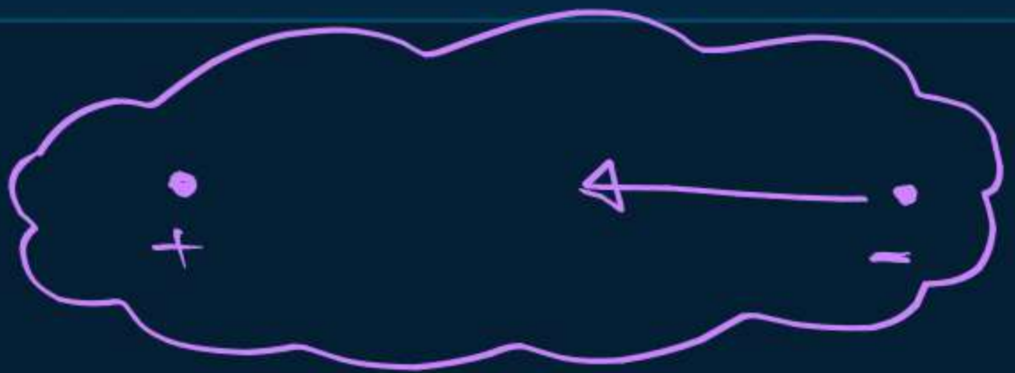
In bringing an electron towards proton, the electrostatic potential energy of the system:

A. Decrease

B. Increase

C. Remain Unchanged

D. IYKYK



Attraction ↑

Stability ↑

PE ↓

Electrostatic Potential

$[V]$

$\Delta V \rightarrow$ Voltage or Potential Difference
or
V

+1C

The work done in bringing a unit positive test charge from infinity to a given point in the electrostatic field of another (source) charge slowly is called the electrostatic potential of the source charge.

$$U = \frac{KQq_0}{r}$$

if we consider, test charge (q_0) to be +1C then U becomes..

$$U = \frac{KQ(+1)}{r} \quad \text{or} \quad \boxed{V = \frac{KQ}{r}}$$

Y.K.B. (Class X)

$Q \longleftarrow r \longrightarrow q_0$

$$U = \frac{KQq_0}{r}$$

Voltage = $\frac{\text{Workdone}}{\text{Charge}}$

$$\boxed{V = \frac{W}{Q}}$$

$$\boxed{V = \frac{U}{q_0}}$$

$U \rightarrow$ Joule

$q_0 \rightarrow$ Coulomb

$V = 5V$

Potential

SI unit (Volts)

Q - - - - - - ?

r

- SI unit → Volts(V)

→ Joule/Coulomb

(JC^{-1})

- Scalar

$$V = \frac{U}{q_0}$$

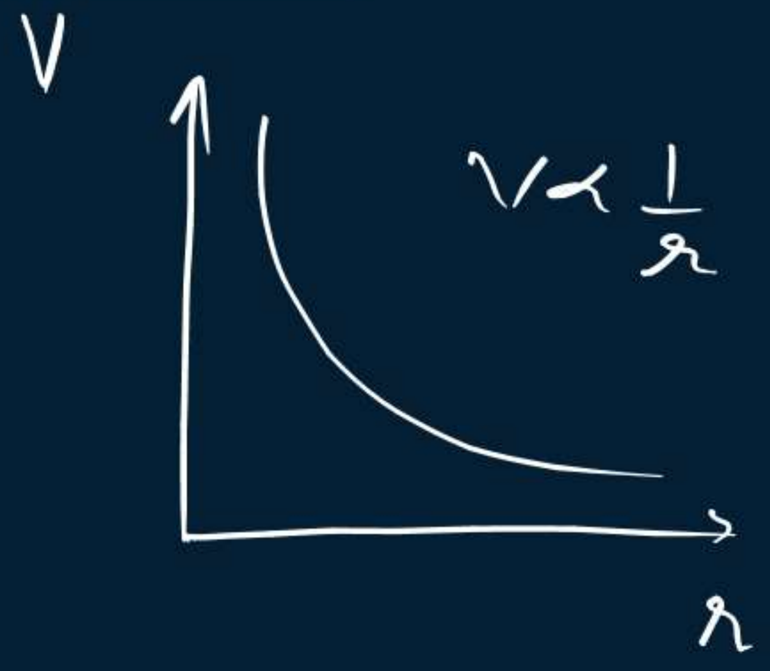
$$= \frac{KQ\cancel{q_0}}{r\cancel{q_0}}$$

$$\boxed{V = \frac{KQ}{r}}$$

Electrostatic Potential for a point charge

$$\boxed{V_p = \frac{kQ}{r}}$$

Potential at Point p

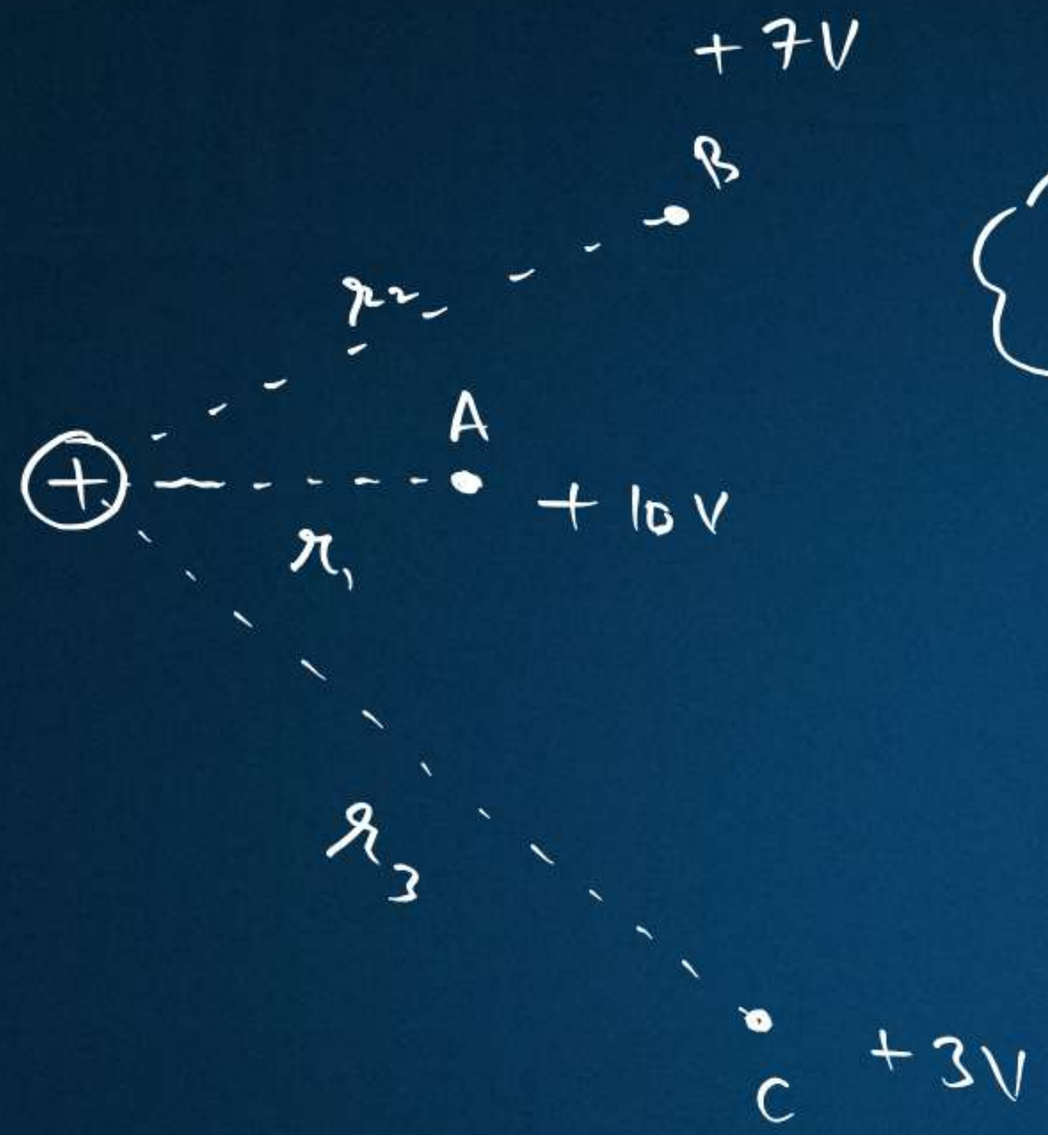


Relation between potential and potential energy

V

U

$$\boxed{V = \frac{U}{q}}$$



$$V_A > V_B > V_C$$

$$V = \frac{KQ}{r}$$

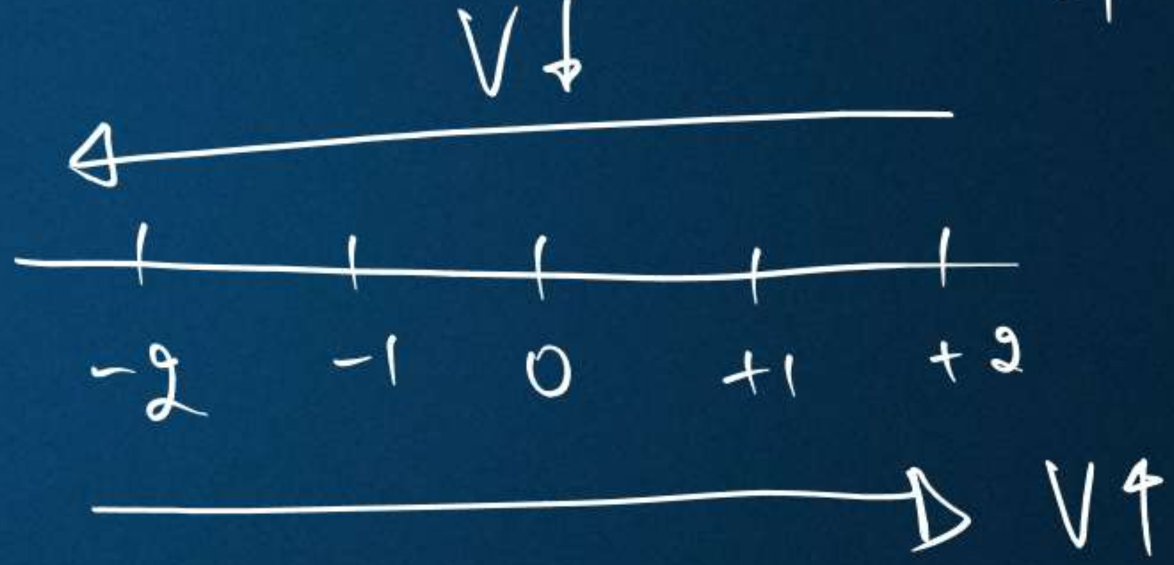
$$V \propto \frac{1}{r\uparrow}$$

$$\boxed{V_A < V_B < V_C}$$

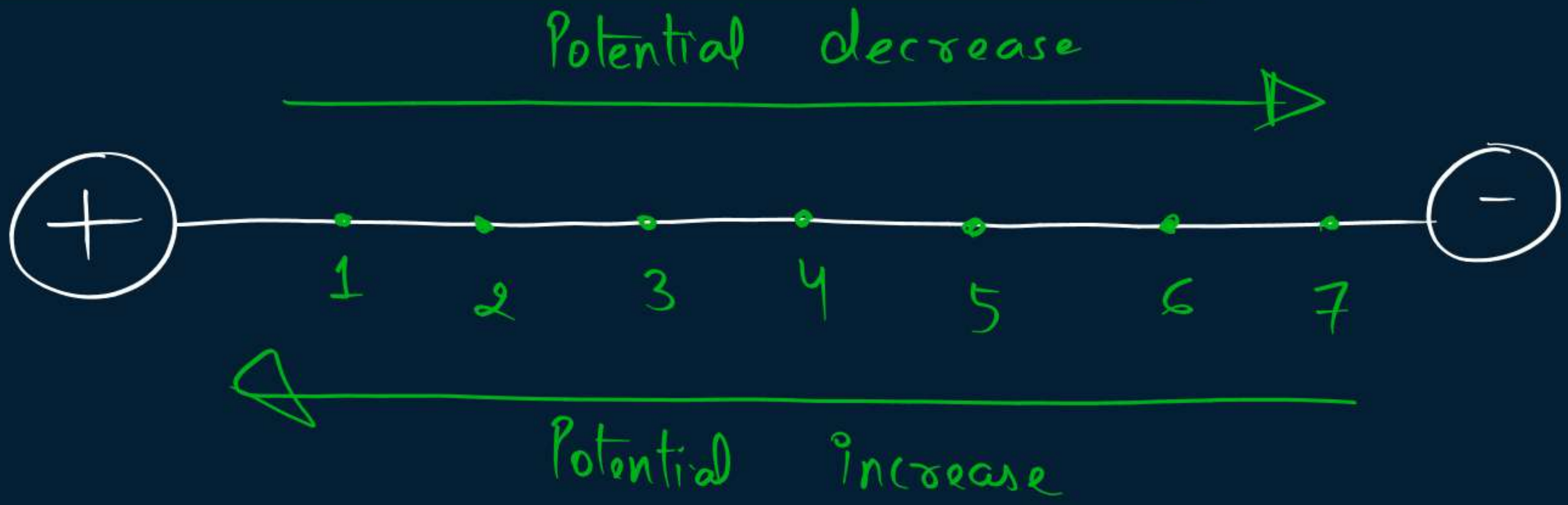
$$V = \frac{k(-Q)}{r}$$

$$V\uparrow \propto \frac{1}{r\downarrow}$$

$$V\downarrow \propto \frac{1}{r\uparrow}$$



RDx about Electrostatic Potential



Homework

Notes

Ques Repeat

DPP-01

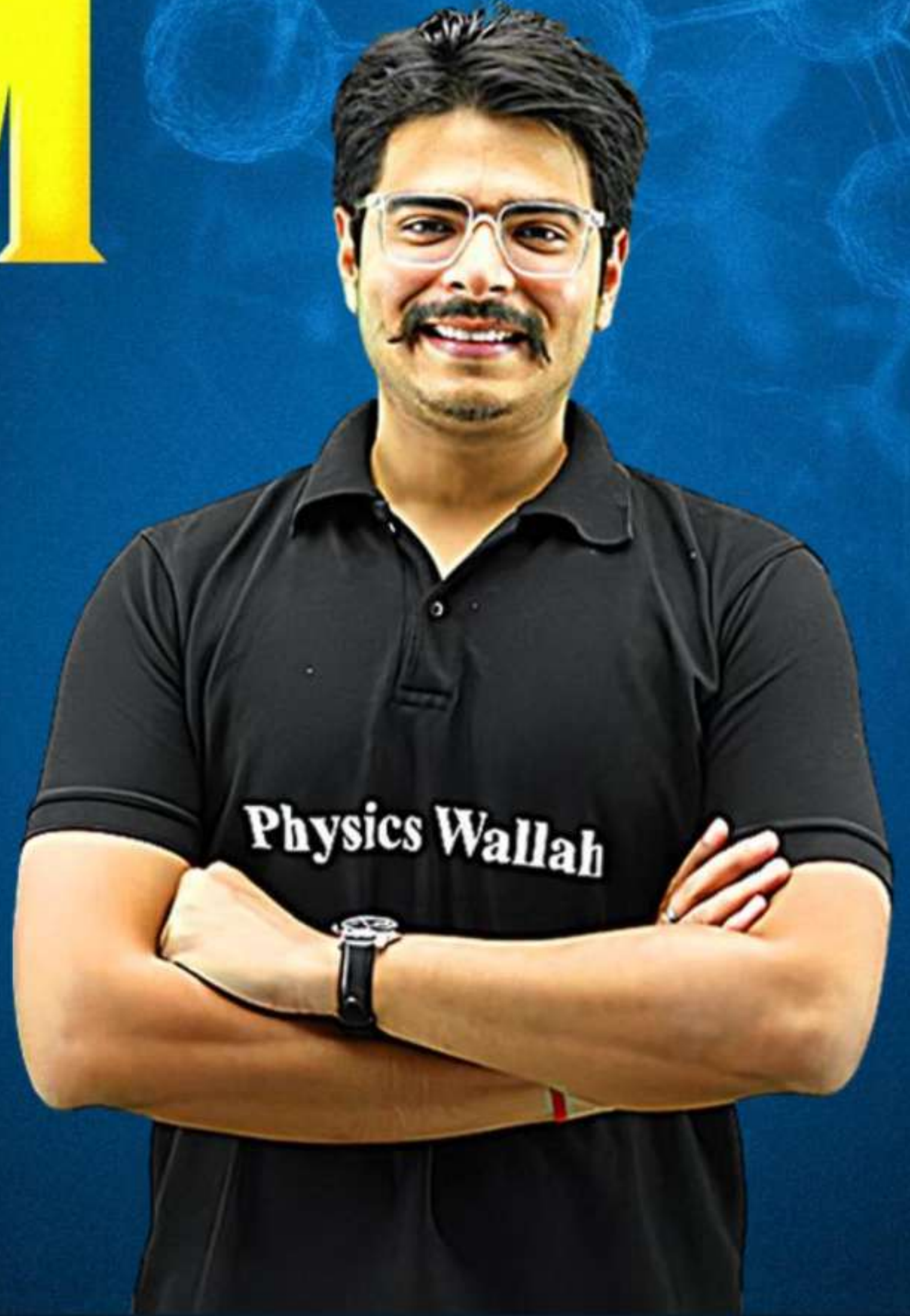
PARISHRAM

2026

Electrostatic Potential and Capacitance

PHYSICS | LECTURE-3

BY - RAKSHAK SIR



Topics *to be covered*

A Potential Difference

B Questions on Potential and Potential Difference

C Imp. Relation Between Potential and Electric Field (* RDx Feel)

D Electric Potential

E

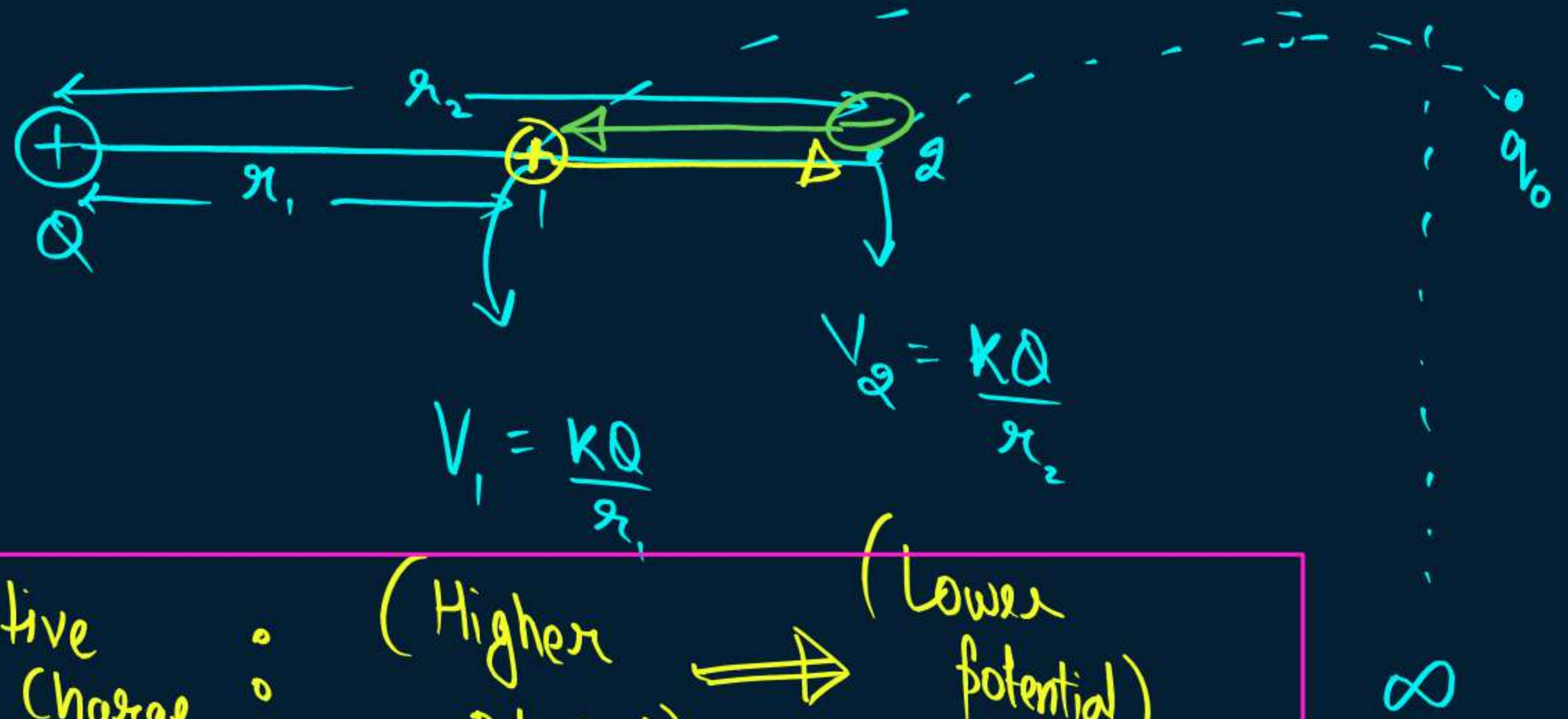
Potential Difference

$$\boxed{\Delta V = V_f - V_i}$$

ΔV → Volts (V)

Y.K.B.

$$V = \frac{KQ}{r}$$



$$V_2 = \frac{KQ}{r_2}$$

$$V_1 = \frac{KQ}{r_1}$$

RDx *

Positive Charge : (Higher Potential) $\Longrightarrow$ (Lower potential)

Negative charge : (higher Pot) $\Longleftarrow$ (Lower Pot)

QUESTION

A charge of 10μC is placed at the origin of *x*-*y* coordinate system. The potential difference between two points (0, a) and (a, 0) in volt will be

x, y (x, y)

A $9 \times 10^4/a$

B $9 \times 10^4/a\sqrt{2}$

C $9 \times 10^4/2a$

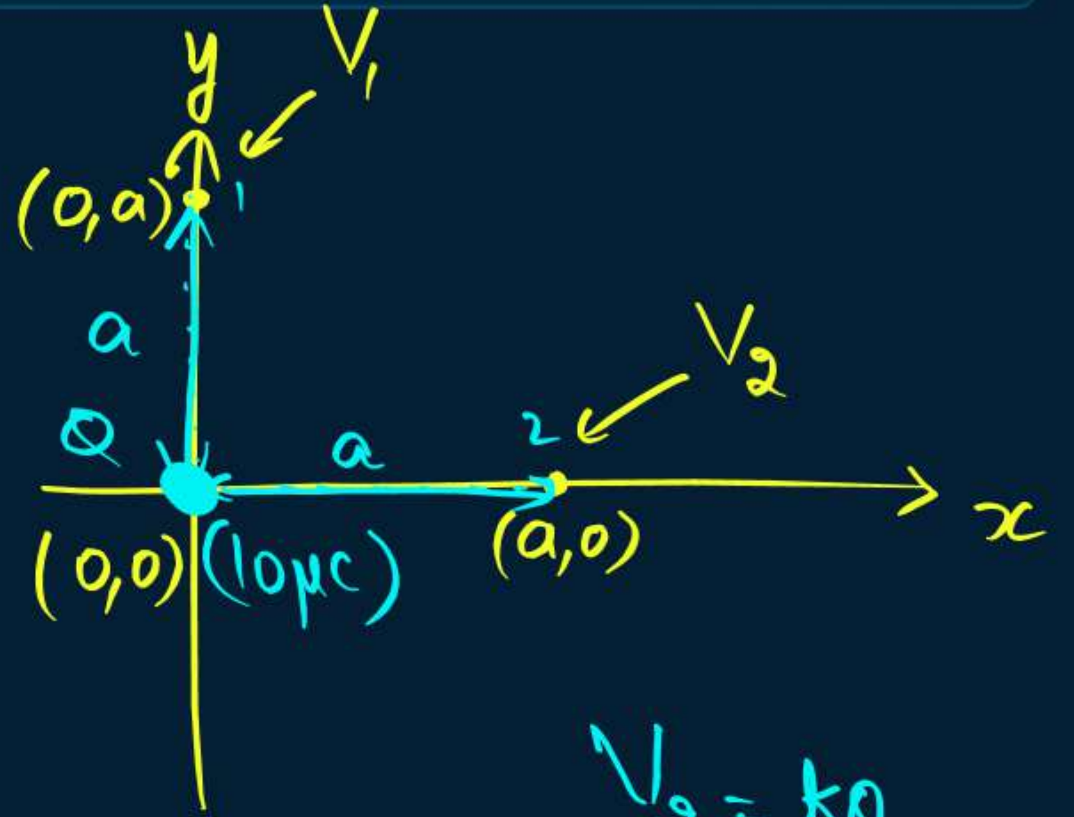
D Zero

$$V_1 = \frac{KQ}{r}$$

$$V_1 = \frac{9\times10^9 \times 10\times10^{-6}}{a}$$

$$\Delta V = V_2 - V_1$$

$$= 0$$

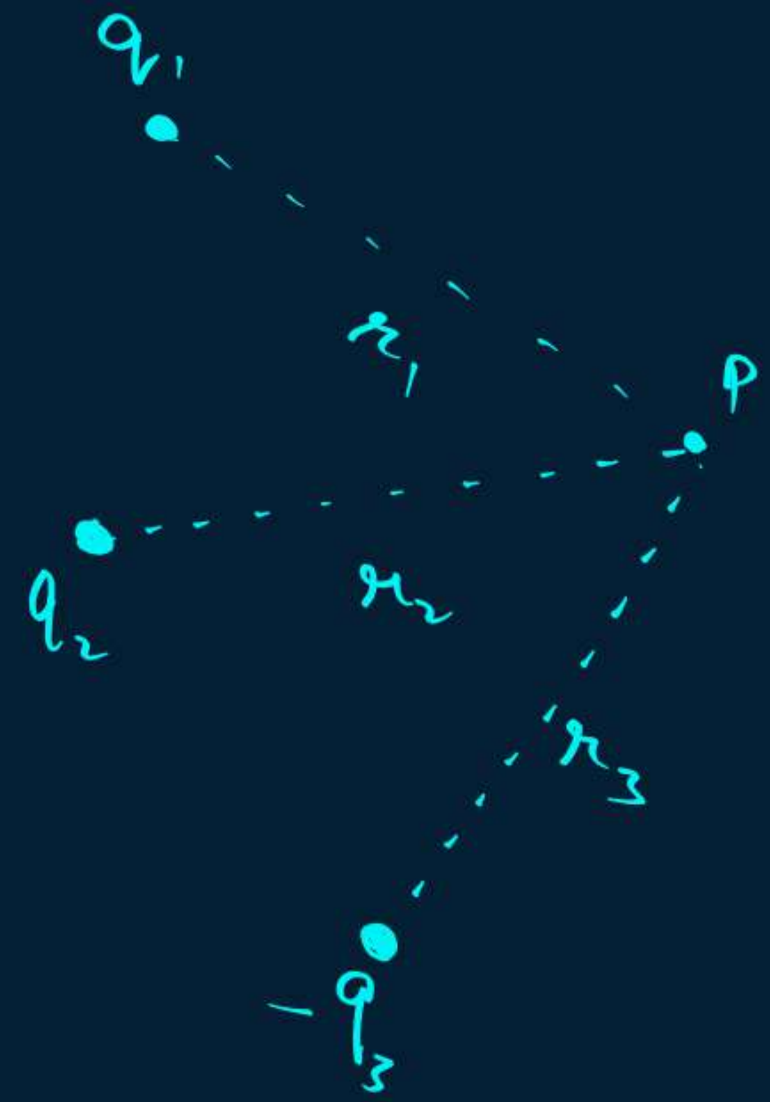


$$V_2 = \frac{KQ}{r}$$

$$= \frac{9\times10^9 \times 10\times10^{-6}}{a}$$

Electrostatic Potential due to multiple charges

Good



$$V_1 = \frac{kq_1}{r_1}$$

$$V_2 = \frac{kq_2}{r_2}$$

$$V_3 = -\frac{kq_3}{r_3}$$

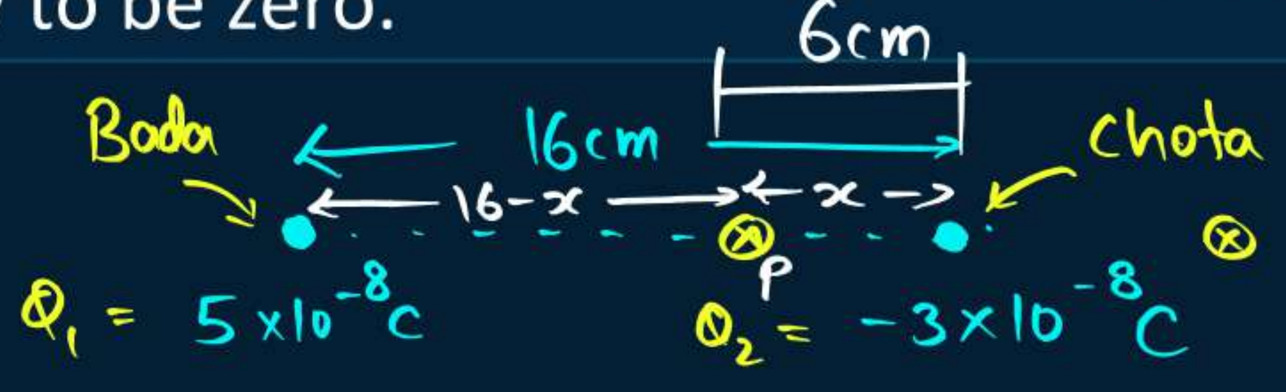
$$V_{net} = V_1 + V_2 - V_3$$

RDx

Jitni Bhi scaler Sum hogi Sabka Sign lagana Jaruri hai

QUESTION

Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero.



Case I: inside Point

$$V_1 = \frac{KQ_1}{16-x}$$

$$V_2 = \frac{KQ_2}{x}$$

$$V_P = V_1 + V_2$$

$$V_1 = \frac{9\times10^9 \times 5\times10^{-8}}{\left(\frac{16-x}{100}\right)}$$

$$V_2 = \frac{9\times10^9 \times (-3\times10^{-8})}{\frac{x}{100}}$$

$$V_P = V_1 + V_2$$

$$0 = \frac{9\times10^9 \times 5\times10^{-8}}{\left(\frac{16-x}{100}\right)} - \frac{9\times10^9 \times 3\times10^{-8}}{\frac{x}{100}}$$

$$\frac{\cancel{9\times10^9} \times 3\times\cancel{10^{-8}}}{\frac{x}{\cancel{100}}} = \frac{\cancel{9\times10^9} \times 5\times\cancel{10^{-8}}}{\frac{(16-x)}{\cancel{100}}}$$

$$\frac{3}{x} = \frac{5}{(16-x)} \rightarrow 48 - 3x = 5x$$

$$48 = 8x$$

$$x = 6\text{cm}$$

Case II

Outside point

Q_1 ———— 16 cm ———— $-Q_2$ ——— $y = 24\text{cm}$ ——— R

$$V_1 = \frac{KQ_1}{(16+y)}$$

$$V_2 = \frac{KQ_2}{y}$$

$$V_R = V_1 + V_2$$

$$0 = \frac{k \times 5 \times 10^{-8}}{\frac{16+y}{100}} - \frac{k \times 3 \times 10^{-8}}{\frac{y}{100}}$$

$$\frac{\cancel{k} \times 3 \times \cancel{10^{-8}}}{\frac{y}{\cancel{100}}} = \frac{\cancel{k} \times 5 \times \cancel{10^{-8}}}{\frac{16+y}{\cancel{100}}}$$

$$\frac{3}{y} = \frac{5}{16+y}$$

$$3(16+y) = 5y$$

$$48 + 3y = 5y$$

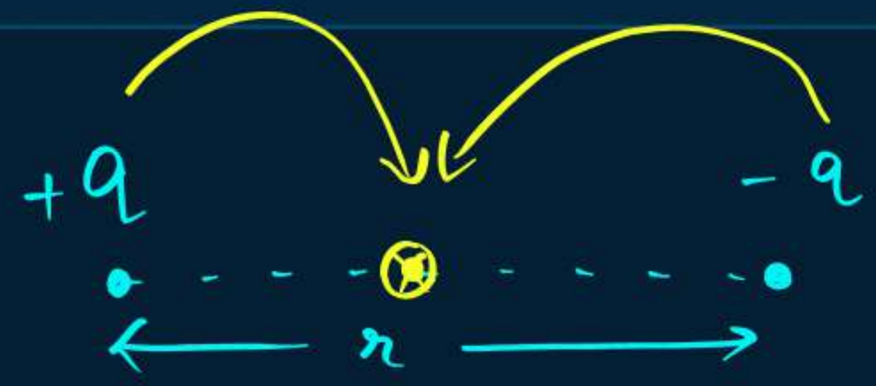
$$48 = 5y - 3y$$

$$48 = 2y$$

$$y = 24\text{ cm} \checkmark$$

QUESTION

Find electric potential at a point midway between the two equal and opposite charges.



$$V_1 = \frac{kq}{\left(\frac{r}{2}\right)}$$

$$V_2 = -\frac{kq}{\left(\frac{r}{2}\right)}$$

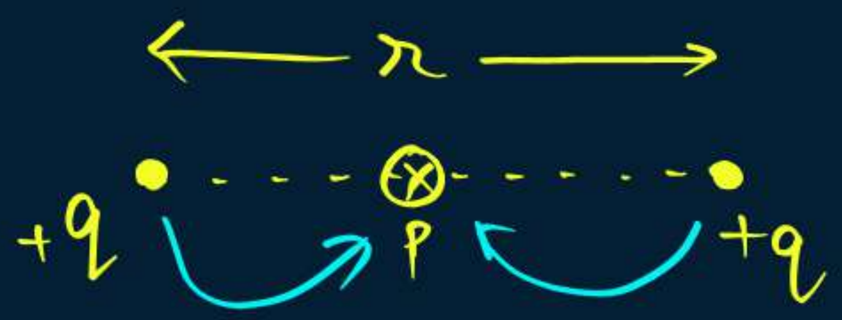
$$V_{net} = V_1 + V_2$$

$$= \cancel{\frac{kq}{\frac{r}{2}}} - \cancel{\frac{kq}{\frac{r}{2}}}$$

$$= 0 \checkmark$$

QUESTION

Find electric potential at a point midway between the two equal and similar charges.



$$V_1 = \frac{kq}{\frac{r}{2}}$$

$$V_2 = \frac{kq}{\frac{r}{2}}$$

$$V_{net} = V_1 + V_2$$

$$= \frac{kq}{\frac{r}{2}} + \frac{kq}{\frac{r}{2}}$$

$$= \frac{2kq}{r} + \frac{2kq}{r}$$

$$\boxed{V_{net} = \frac{4kq}{r}}$$

QUESTION

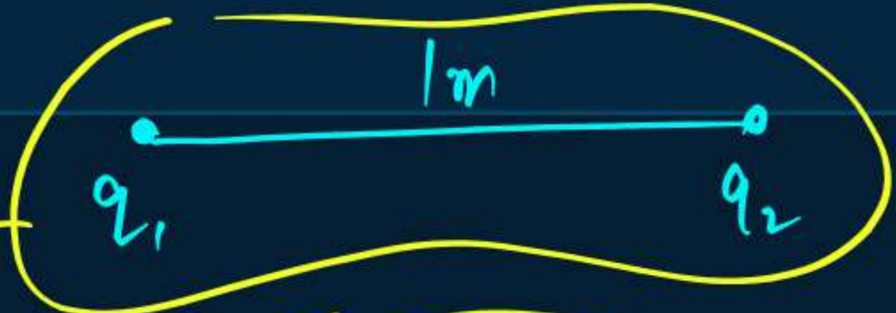
Charges 5μC and 10 μC are placed 1 m apart. Work done to bring these charges at a distance 0.5 m from each other is:

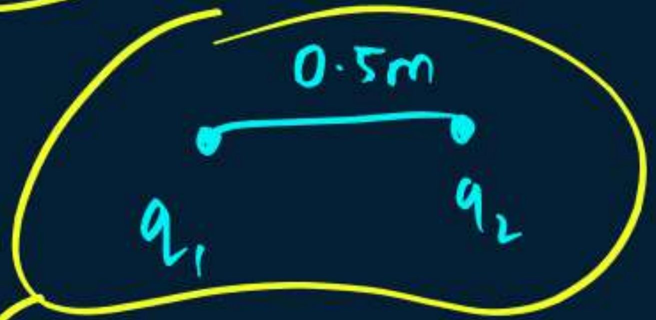
A) 9×10^{4} J

B) 18×10^{4} J

C) 45×10^{-2} J

D) 9×10^{-1} J





$$U_1 = \frac{kq_1q_2}{r}$$

$$= \frac{9\times10^{9} \times 5\times10^{-6} \times 10\times10^{-6}}{1}$$

$$U_2 = \frac{9\times10^{9} \times 5\times10^{-6} \times 10\times10^{-6}}{\frac{1}{2}}$$

$$= 2 \times [\quad]$$

$$\boxed{W_{ext} = \Delta U}$$

$$W_{cf} = -\Delta U$$

$$\boxed{W_{ext} = \Delta U}$$

$$= U_2 - U_1$$

$$= 9\times10^{9} \times 5\times10^{-6} \times 10\times10^{-6}\,[2-1]$$

$$= 45 \times 10^{-2}$$

$$= 0.45\ \text{J}$$

Relation between Electric (V) Potential and Electric Field (E)

$$W_{cf} = -\Delta U$$

$$W_{elec} = -\Delta U$$

Small change

$$dW_{elec} = -dU$$

$$dU = -dW_{elec}$$

Integrate both sides...

$$\int dU = -\int dW_{elec}$$

$$\int q \cdot dV = -\int F \cdot dr$$

$$\int \cancel{q} \cdot dV = -\int \cancel{q} E \cdot dr$$

$$\int dV = -\int \vec{E} \cdot d\vec{r}$$

$$V = -\int \vec{E} \cdot d\vec{r}$$

Y.K.B.

$$W = \vec{F} \cdot \vec{s}$$

$$dW = \vec{F} \cdot d\vec{r}$$

$$F = qE$$

Y.K.B.

$$V = \frac{U}{q}$$

$$\Delta V = \frac{\Delta U}{q}$$

$$\Delta U = q\Delta V$$

Small change

$$dU = q\,dV$$

* $\boxed{\vec{E} = -\frac{dV}{dr}}$

* $\boxed{V = -\int \vec{E} \cdot d\vec{r}}$

$$\vec{E} = -\frac{dV}{dr} \rightarrow \frac{V}{l} \rightarrow \left(\frac{\text{Volts}}{\text{metre}}\right)$$

or

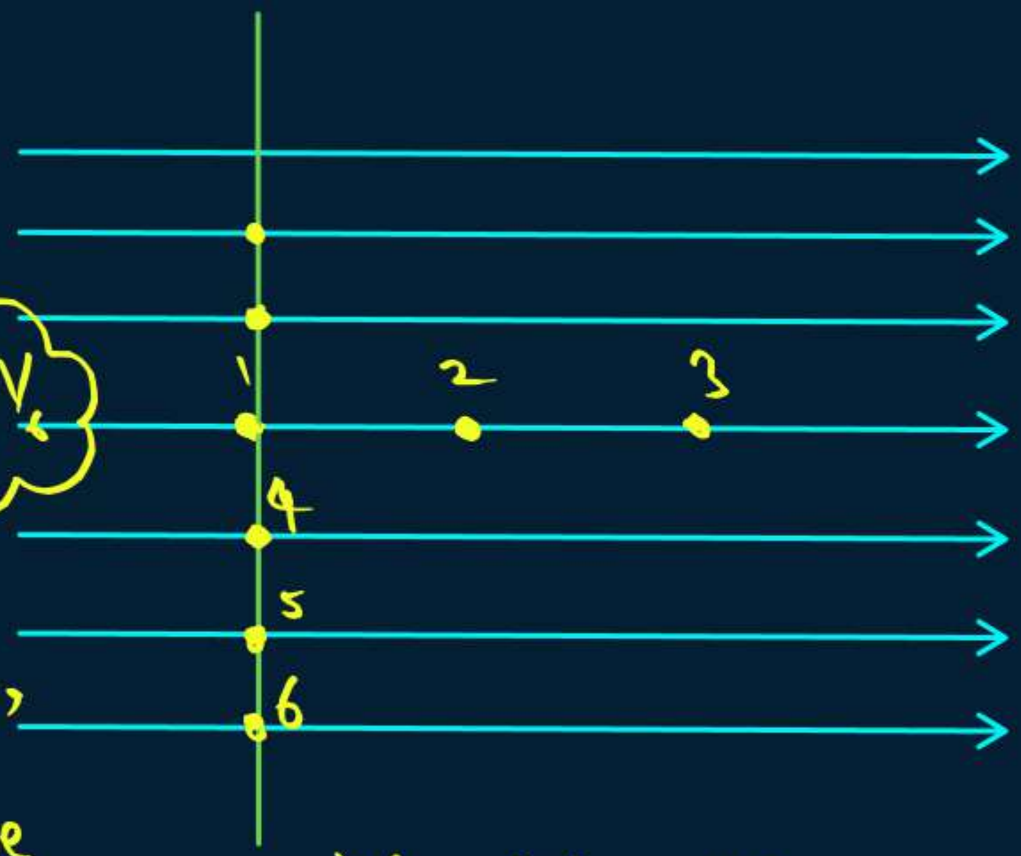
$$(V/m)$$

RDx Feel

$$\boxed{\vec{E} = -\frac{dV}{dr}}$$

→ rate of decremental change in potential is equal to the magnitude of Electric field.

* Agar hum Electric field ki Direction Mein aage Badhenge toh Potential ki Value decrease hogi.



$V_1 = V_4 = V_5 = V_6$

laterally moving, potential Will be same

$V_1 > V_2 > V_3$

Potential Ka rate distance ke hisaab se Negatively change hoga. (Ghatega)

$$\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$$

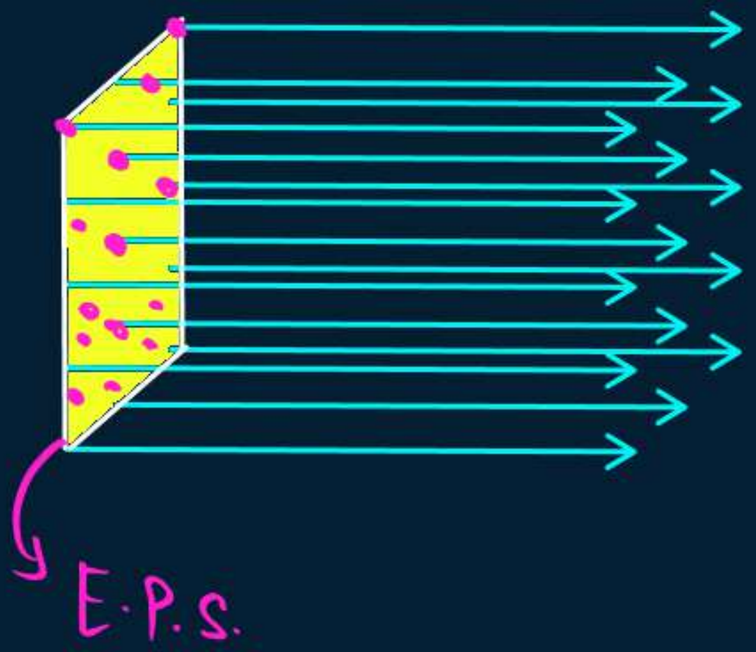
$$\vec{E} = -\frac{dV}{dr}$$

$$\boxed{E_x = -\frac{\partial V}{\partial x}}$$

$$\boxed{E_y = -\frac{\partial V}{\partial y}}$$

$$\boxed{E_z = -\frac{\partial V}{\partial z}}$$

All the points having same potential have a locus called Equipotential surface.
(EPS)



QUESTION

The electric potential V at any point (x, y, z) all in metres in space is given by $V = 4x^2$ volt. The electric field at the point (1,0,2) in volt/metre is

A) 8 along negative X-axis

B) 8 along positive X-axis

C) 16 along negative X-axis

D) 16 along positive Z-axis

$$V = 4x^2$$

$$\frac{\partial V}{\partial x} = 4(2x)$$

$$\frac{\partial V}{\partial x} = 8x$$

$$E_x = -\frac{\partial V}{\partial x}$$

$$E_x = -8x$$

$$E_x = -8 \times 1$$

$$E_x = -8\ N/C$$

$$E_x = -8\ V/m$$

QUESTION

A, B and C are three points in a uniform electric field. The electric potential is

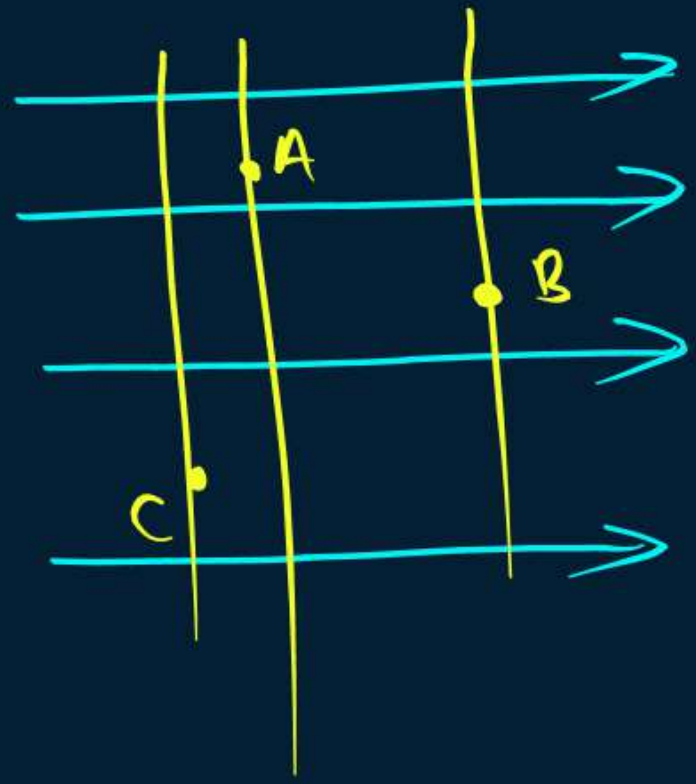
A maximum at A.

B maximum at B.

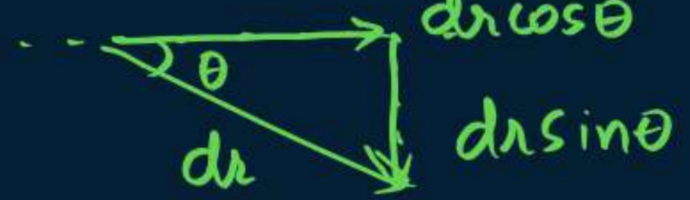
C maximum at C.

D same at all the three points A, B and C.

$C > A > B$



QUESTION



Three points A, B and C lie in a uniform electric field (E) of 5×10^3 NC^{-1} as shown in the figure. Find the potential difference between A and C.

$E = 5 \times 10^3$ N/C

$\Delta V = ??$

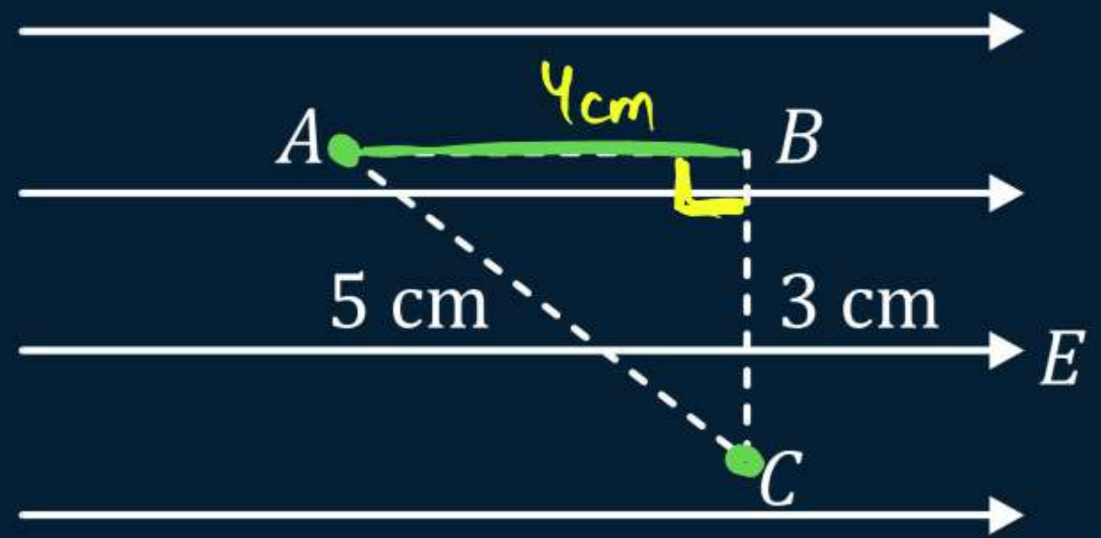
$dV = ??$

$\vec{E} = -\frac{dV}{dr}$

$-\vec{E} \cdot d\vec{r} = dV$

$-|\vec{E}||d\vec{r}|\cos\theta =$

$-\cancel{5} \times 10^{\cancel{3}\,2} \times \frac{\cancel{4}\,2}{\cancel{100}\,\cancel{50}\,1\cancel{0}} = -200\,V$



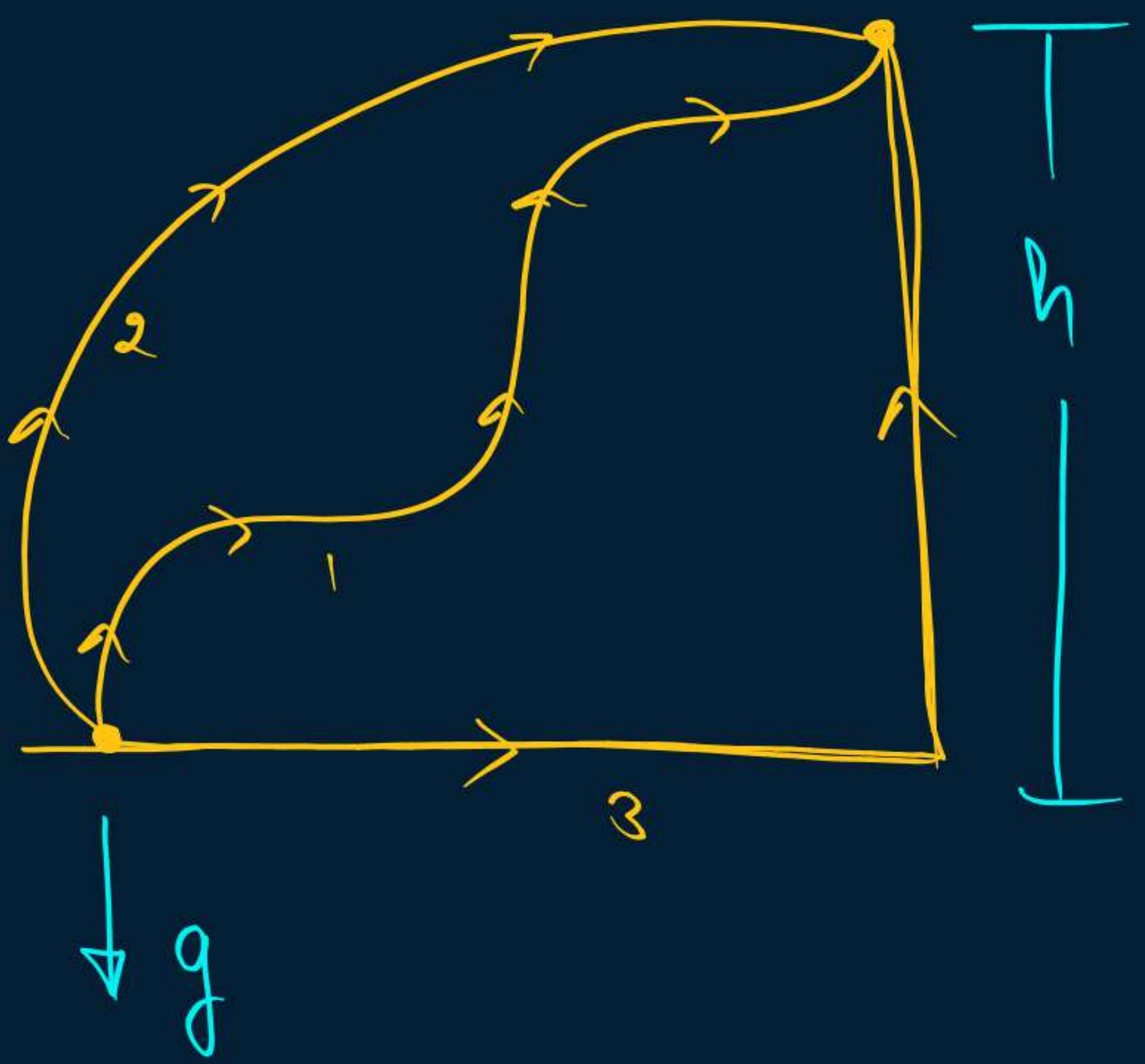
RD$_x$ – Distance Voh lena hai Jo field Ki Disha meho.

$W_{ext} = \Delta U$

Y.K.B.

Same ΔU

Same W_{ext}



QUESTION

$10 - 3 = +7$
$3 - 10 = -7$

In a uniform electric field $\vec{E} = 10$ N/C as shown in figure, find:

(i) $V_A - V_B = \Delta V_{AB}$

(ii) $V_B - V_C = \Delta V_{BC}$

i) $V_B - V_A = +(10V)$

$dV = \bar{E}\, d\bar{r}$

$= E\, dr\cos\theta$

$= 10 \times 1$

$dV_{BA} = 10$ V

$\Delta V_{BA} = 10V$

$\Delta V_{BA} = 10V$

$V_B - V_A = 10V$

$\boxed{V_A - V_B = -10V}$

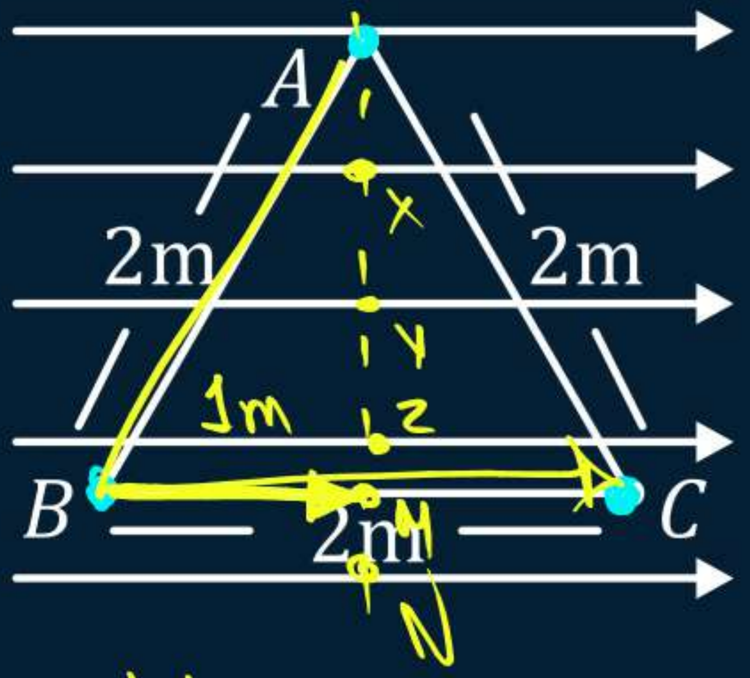
ii) $V_B - V_C = \Delta V_{BC} = 20V$

$dV = \bar{E} \cdot d\bar{r}$

$= E\, dr\cos\theta$

$= 10 \times 2$

$dV = 20$ V



$V_C < V_A < V_B$

Work done in terms of potential difference

$$W_{elec} = -\Delta U$$

$$\Delta U = q\Delta V$$

$$W_{ext} = \Delta U$$

$$\boxed{W_{ext} = q\Delta V}$$

10th Class

$$\boxed{\Delta V = \frac{W_{ext}}{q}}$$

QUESTION

Kuch Nahi : only for confusion.

The work done in bringing a 20 coulomb charge from point A to point B for distance 0.2 m is 2 J. The potential difference between the two points will be (in volt):

A 0.2

B 8

C 0.1

D 0.4

$$W_{ext} = q(\Delta V)$$

$$2 = 20 \times (\Delta V)$$

$$\frac{\cancel{2}\,1}{\cancel{20}\,10} = \Delta V$$

$$\boxed{\Delta V = 0.1 \text{ Volts}}$$

Homework

Notes

Sawaal Phinse ✓

DPP

PARISHRAM

2026

Lecture-04

Electrostatic Potential and Capacitance

PHYSICS **LECTURE-4**

BY - RAKSHAK SIR

Topics *to be covered*

A. Practice Questions on relation between E and V
B. Potential of Various Bodies (Misc.)
C. Equipotential Surface and its properties
D. Potential and Potential Energy in Dipole
E.

QUESTION Correction (Last Lec)

$10 - 3 = +7$
$3 - 10 = -7$

In a uniform electric field $\vec{E} = 10$ N/C as shown in figure, find:

(i) $V_A - V_B = \Delta V_{AB}$

(ii) $V_B - V_C = \Delta V_{BC}$

i) $V_B - V_A = +(10V)$

$dV = -\bar{E}\, d\bar{r}$

$= -E\, dr\cos\theta$

$= -10 \times 1$

$dV_{BA} = -10\ V$

$\Delta V_{BA} = -10V$

$\Delta V_{BA} = -10V$

$V_B - V_A = -10V$

$\boxed{V_A - V_B = +10V}$ ✓

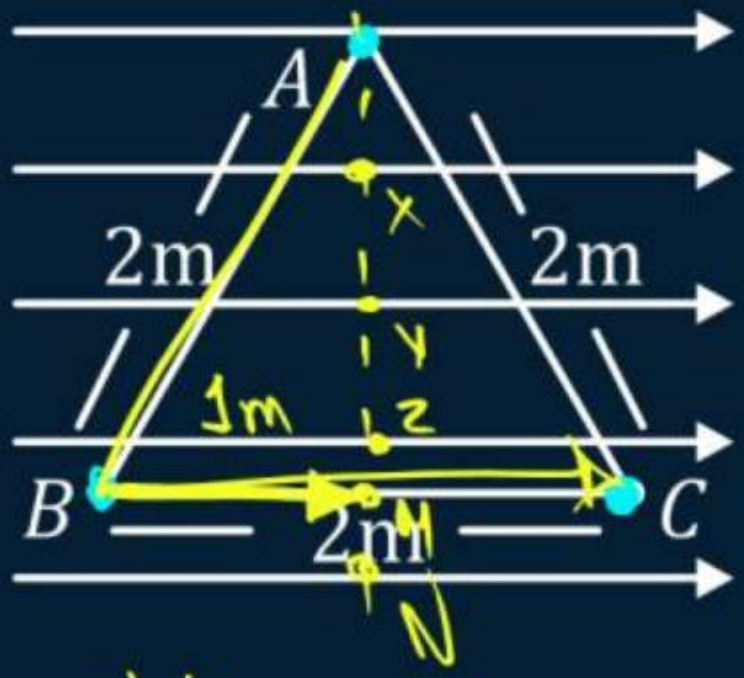
ii) $V_B - V_C = \Delta V_{BC} = -20V$

$dV = -\bar{E}\cdot d\bar{r}$

$= -E\, dr\cos\theta$

$= -10 \times 2$

$dV = -20\ V$



$V_C < V_A < V_B$

QUESTION

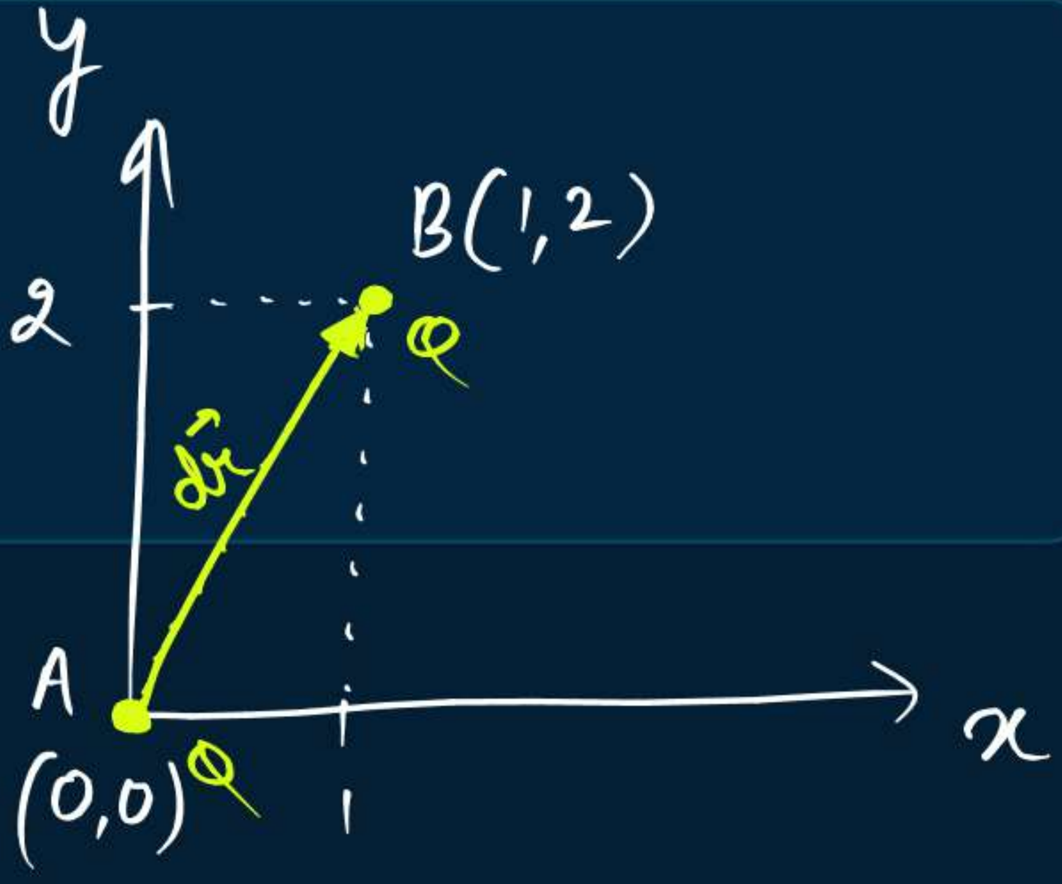
JEE PYQ

A proton is moved from A(0,0) to B(1,2)

$\vec{E} = (2\hat{i} + 3\hat{j})\ V/m$

Find :

1. Vab
2. If Va = 0 then Vb = ?



$\vec{E} = 2\hat{i} + 3\hat{j}$

1.) $V_{AB} \Rightarrow ?$

$\boxed{dV = -\vec{E}\cdot d\vec{r}}$

$dV = -(2\hat{i} + 3\hat{j})\cdot(\hat{i} + 2\hat{j})$

$= -(2+6)$

$\Delta V = dV = -8$ Volts

$d\vec{r} = 1\hat{i} + 2\hat{j}$

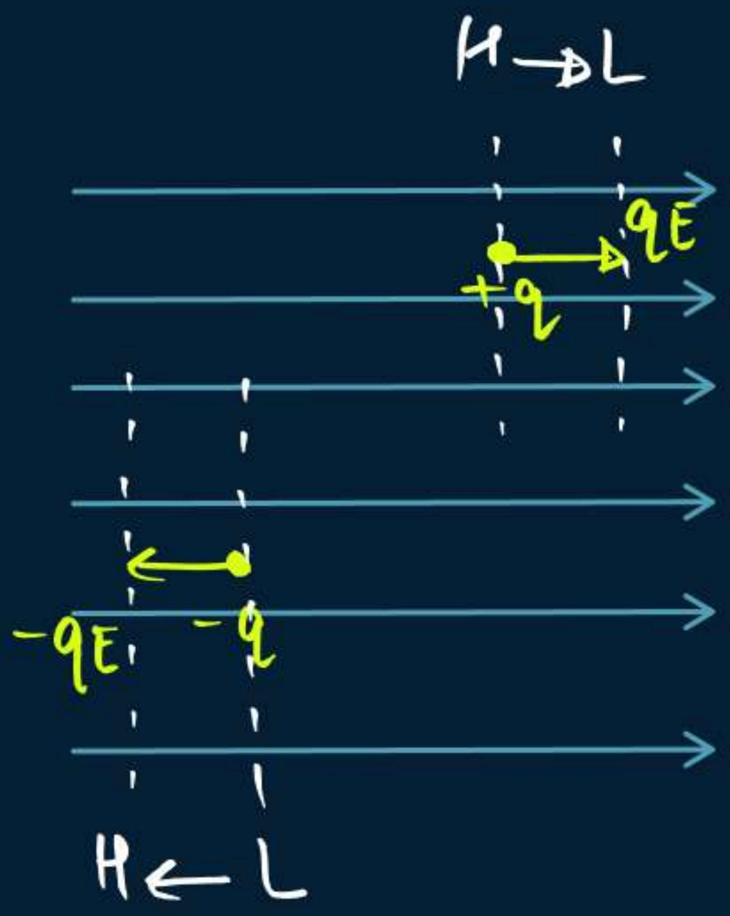
2. $\Delta V_{AB} = V_A - V_B$

$-8 = 0 - V_B$

$+8 = +V_B$

$V_B = 8$ Volts

Free Charge in Electric Field



	U	V
⊕	decrease (stable)	decrease (H → L)
⊖	decrease (stable)	increase (L → H)

QUESTION

A positive and negative charges are set free in electric field, they move in a direction where potential energy

A. Increases, Decreases

B. Decreases, Increases

C. Decreases, Decreases

D. Increases, Increases

QUESTION

$K = \frac{1}{2}mv^2$

A proton is accelerated from $\boxed{\text{rest}}$ through a potential difference of 500 volts. The final kinetic energy is?

$K_i = \frac{1}{2}mu^2$ $\quad$ $K_f = \frac{1}{2}mv^2$

$K_i = 0$ $\quad$ $K_f = K$

Work-Energy Theorem : $\boxed{W = \Delta K}$

$W = K_f - K_i$

$W = K - 0$

$\boxed{W = K}$

$W = q\Delta V$

* $\boxed{q\Delta V = K}$

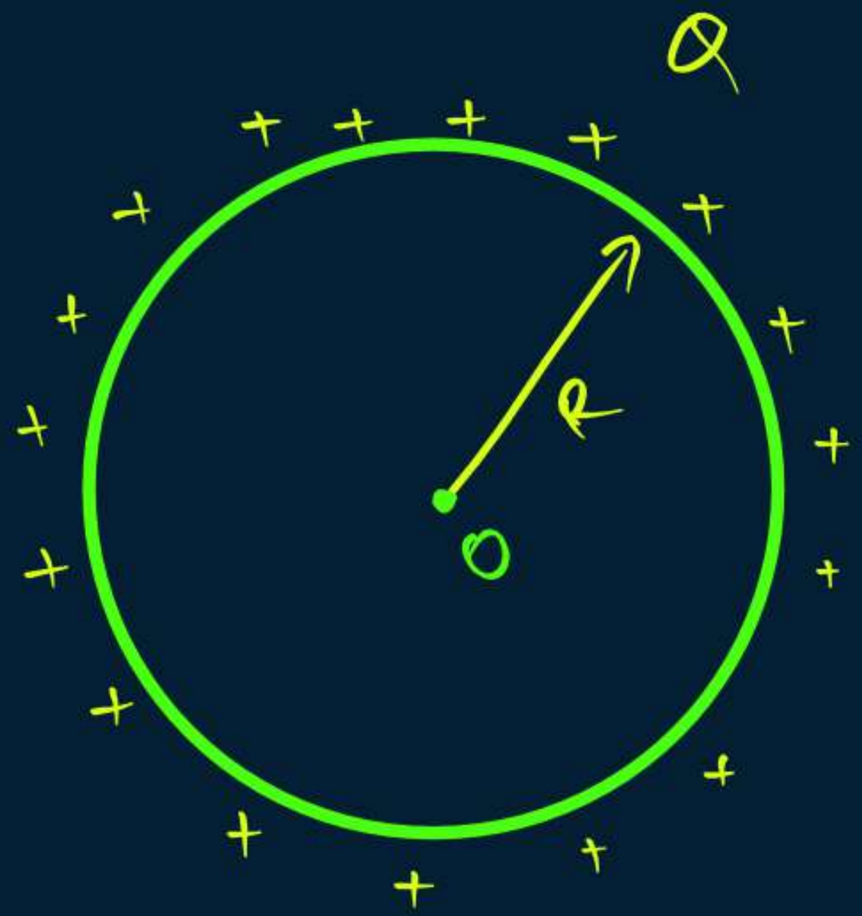
Relation b/w Kinetic Energy and Potential Difference

$KE = q\Delta V$

$= 1.6 \times 10^{-19} \times 500$

$=$ J

Electric Potential due to Ring



$$\boxed{V_{at\ O} = \frac{kQ}{R}}$$

$E_{at\ O}$ = Zero

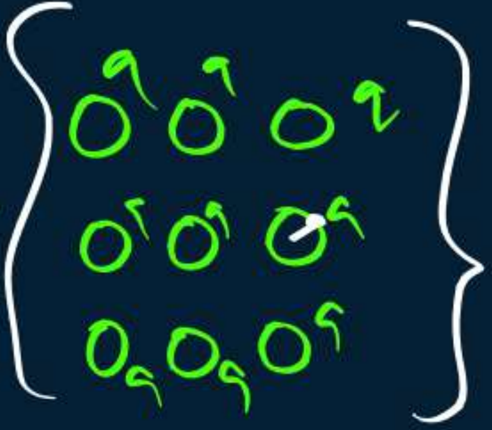
Electric Potential due to Combination of Drops (Coalescence)

JEE|NEET|BOARDS

number = n

radius = r

charge = q



n-drops

V

1 drop :- $V = \frac{kq}{r}$

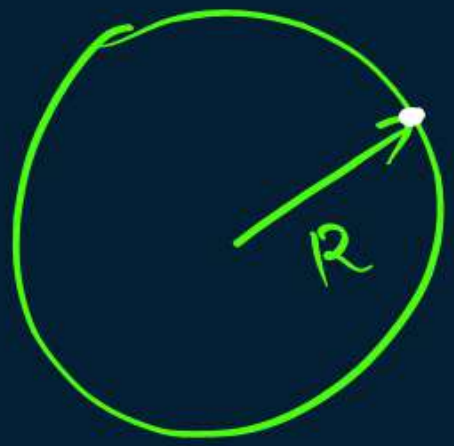
$\text{Volume of } n\text{-drops} = \text{Volume of Big drop}$

$$n \times \cancel{\frac{4}{3}}\cancel{\pi} r^3 = \cancel{\frac{4}{3}}\cancel{\pi} R^3$$

$$n r^3 = R^3$$

$$\boxed{n^{\frac{1}{3}} r = R}$$

cube root



Big drop

$$Q = q + q + q + q \ldots n$$
$$= nq$$

$$V' = \frac{kQ}{R}$$

$$= \frac{knq}{n^{\frac{1}{3}} r}$$

$$= \frac{n}{n^{\frac{1}{3}}}\left(\frac{kq}{r}\right)$$

$$* \quad = n^{1-\frac{1}{3}} V$$

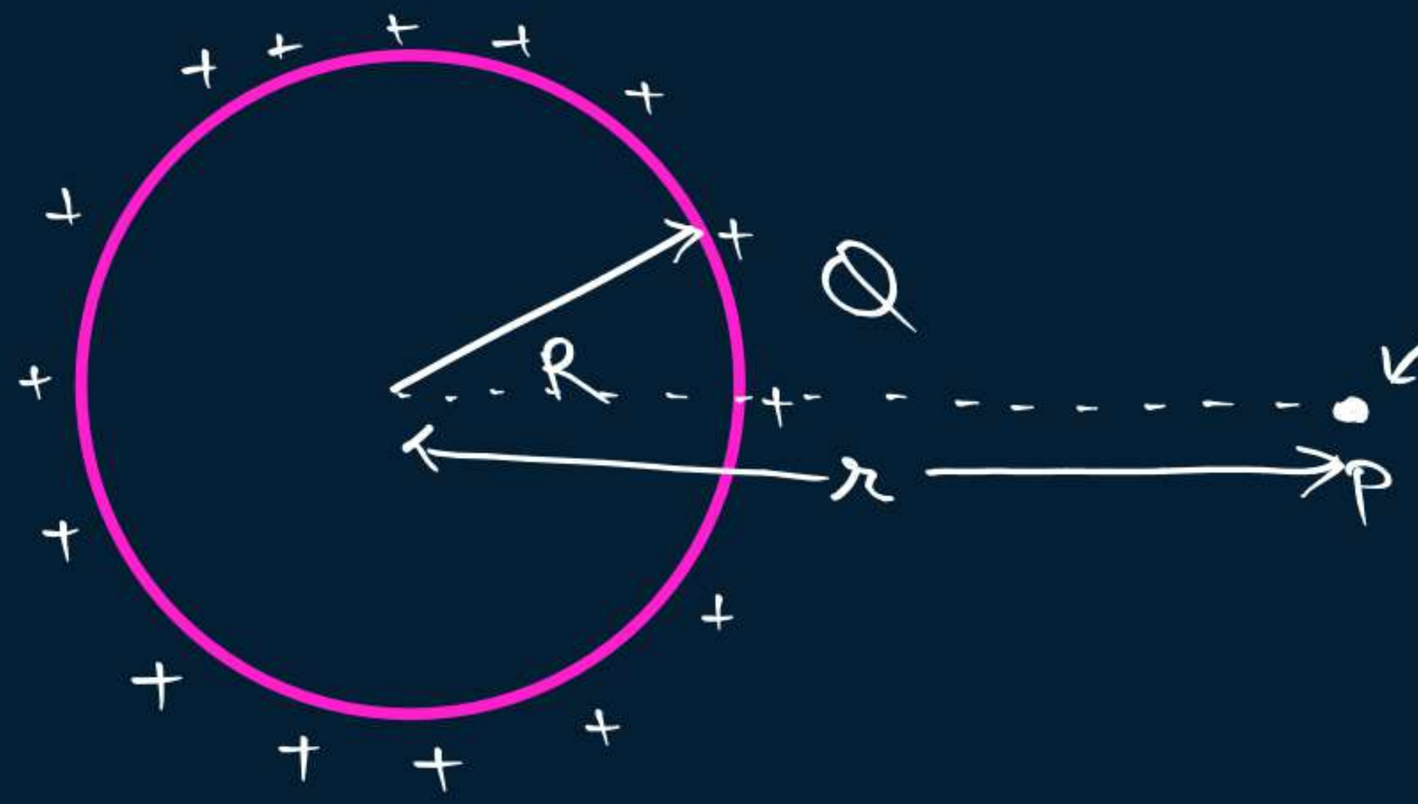
$$\boxed{V' = n^{2/3} V}$$

Electric Potential due to uniformly charged thin Spherical Shell

Football

1. When P is outside (r > R)

   We know E.F. outside the shell is as entire charge is concentrated at the centre.

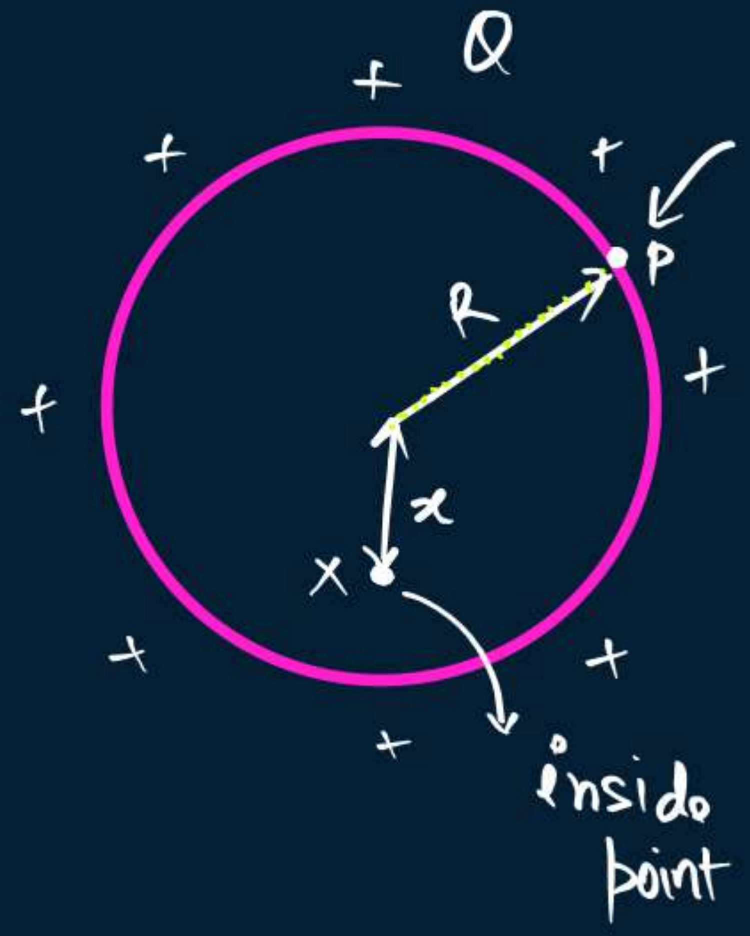


$$\boxed{V_P = \frac{kQ}{r}}$$

outside point

Derivation: Potential due to uniformly charged thin Spherical Shell

2. When P on the surface (r > R)
   Put r = R in ...(1)
   $\therefore V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ [for r < R]



surface point

$\boxed{V_P = \frac{kQ}{R}}$

$E_x = 0$

$V_x = \frac{kQ}{R}$

Y.K.B.

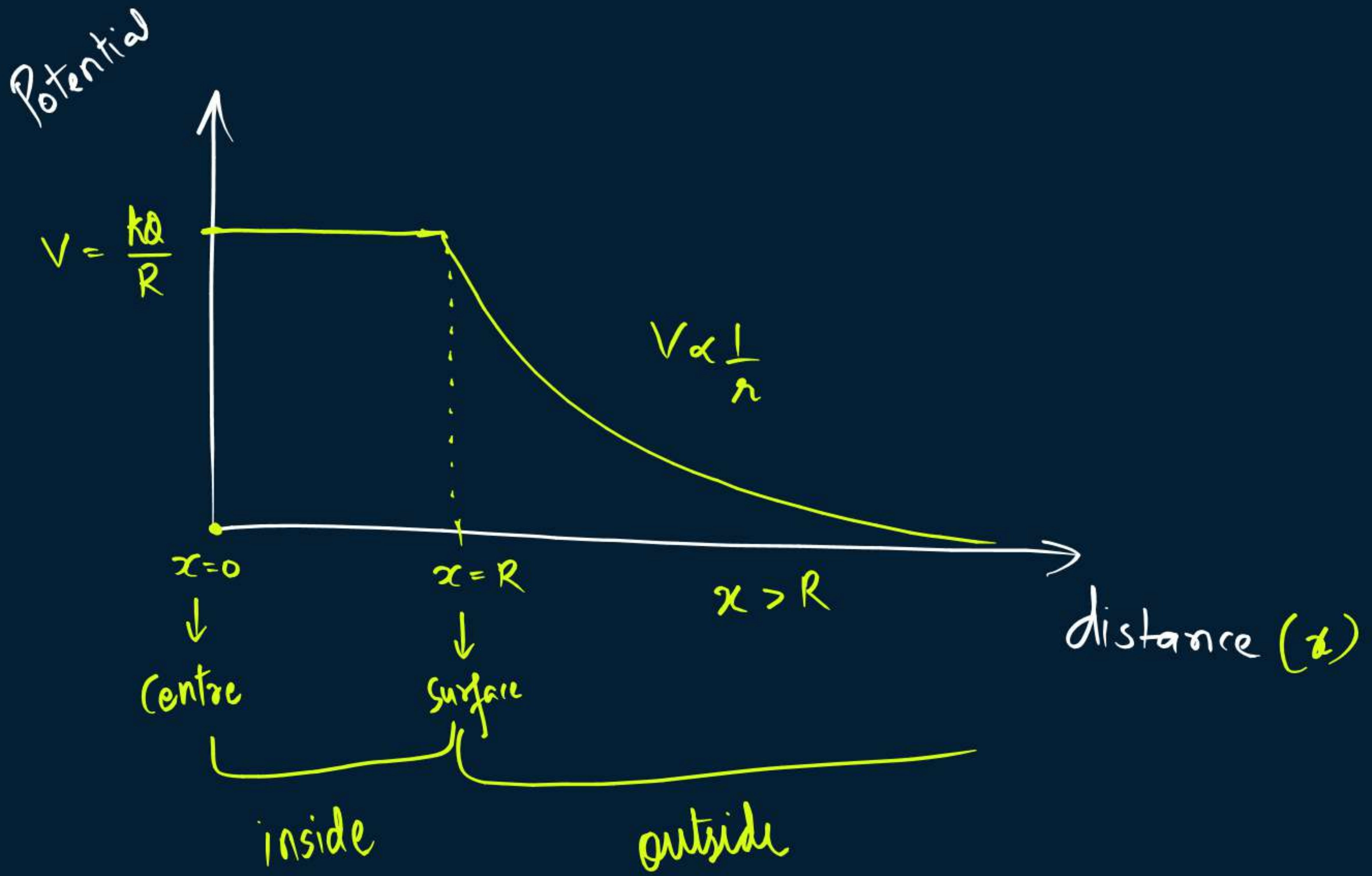
$\vec{E} = -\frac{dV}{dr}$

$E_{inside} = 0$

$0 = \frac{dV}{dr}$

$V = \text{Constant}$

3. When P inside the shell (r < R)
   E.F. at any pt. inside the shell is zero. Hence V is constant everywhere inside the shell and equal to V at surface.

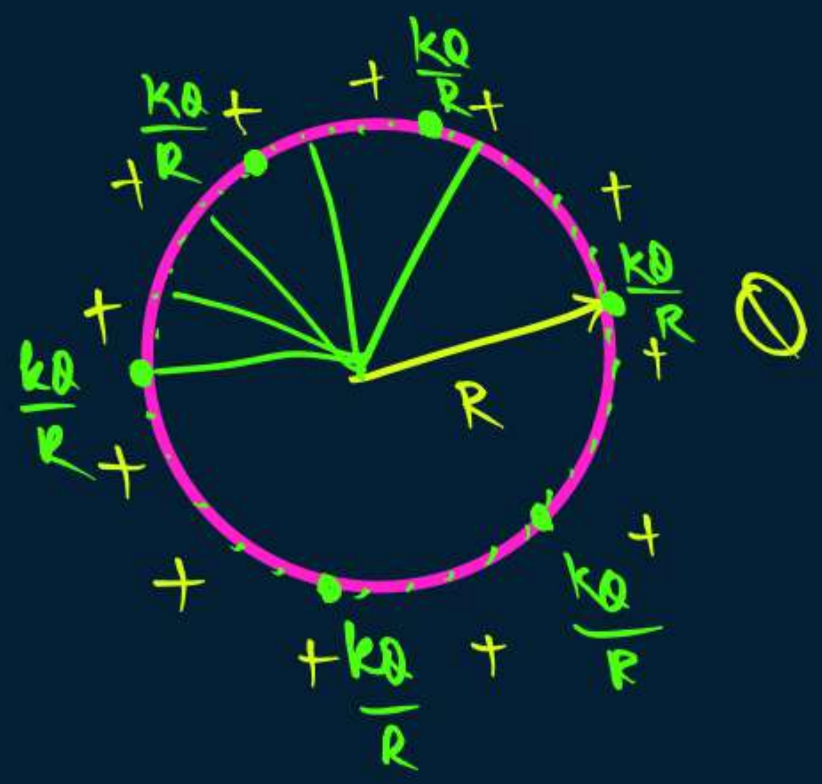

Potential
$V = \frac{kQ}{R}$
$V \propto \frac{1}{r}$
$x=0$
$x=R$
$x>R$
distance (x)
centre
surface
inside
outside

Equipotential Surface

E.P.S.

Any surface has same potential at every point on the surface.

Example: Surface of a charged conductor.



Properties of Equipotential Surface

1. No work done moving q on E.P.S.

2. $\vec{E} \perp$ E.P.S.

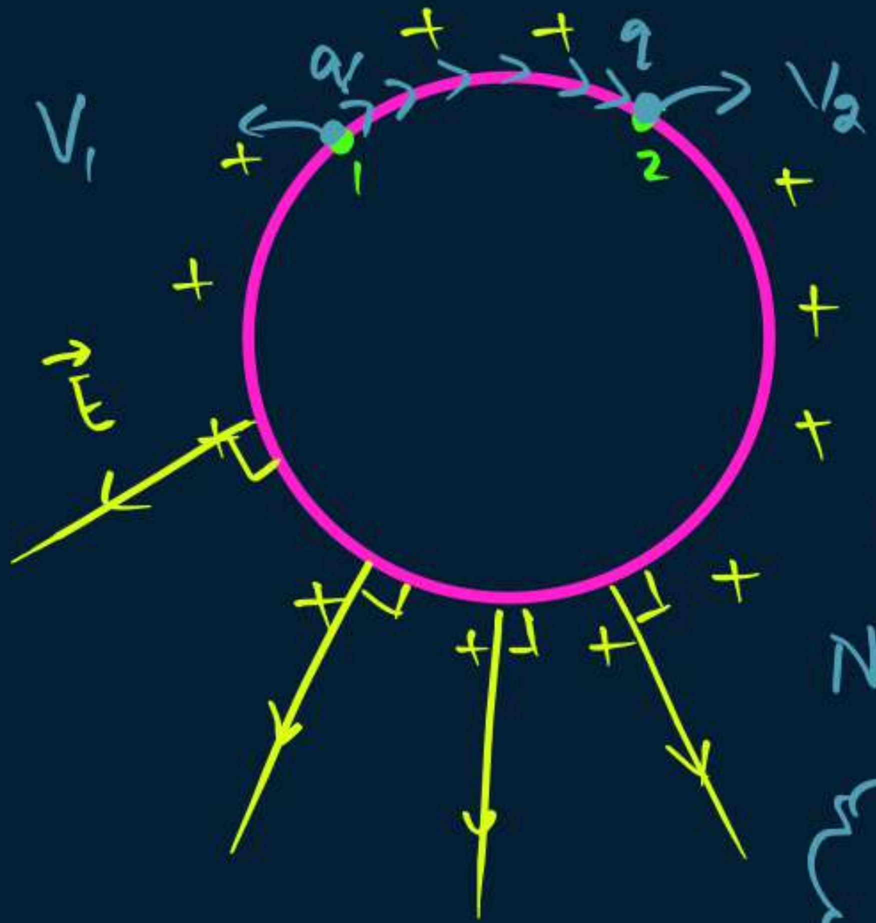
3. E.P.S. is closer in strong E.F. and Vice Versa

4. No intersection of E.S.

$W = q(\Delta V)$

$W = q(V_2 - V_1)$

$= q \times 0 = 0$



$V_1 = V_2$

(E.P.S.)

No Pot" Diff"

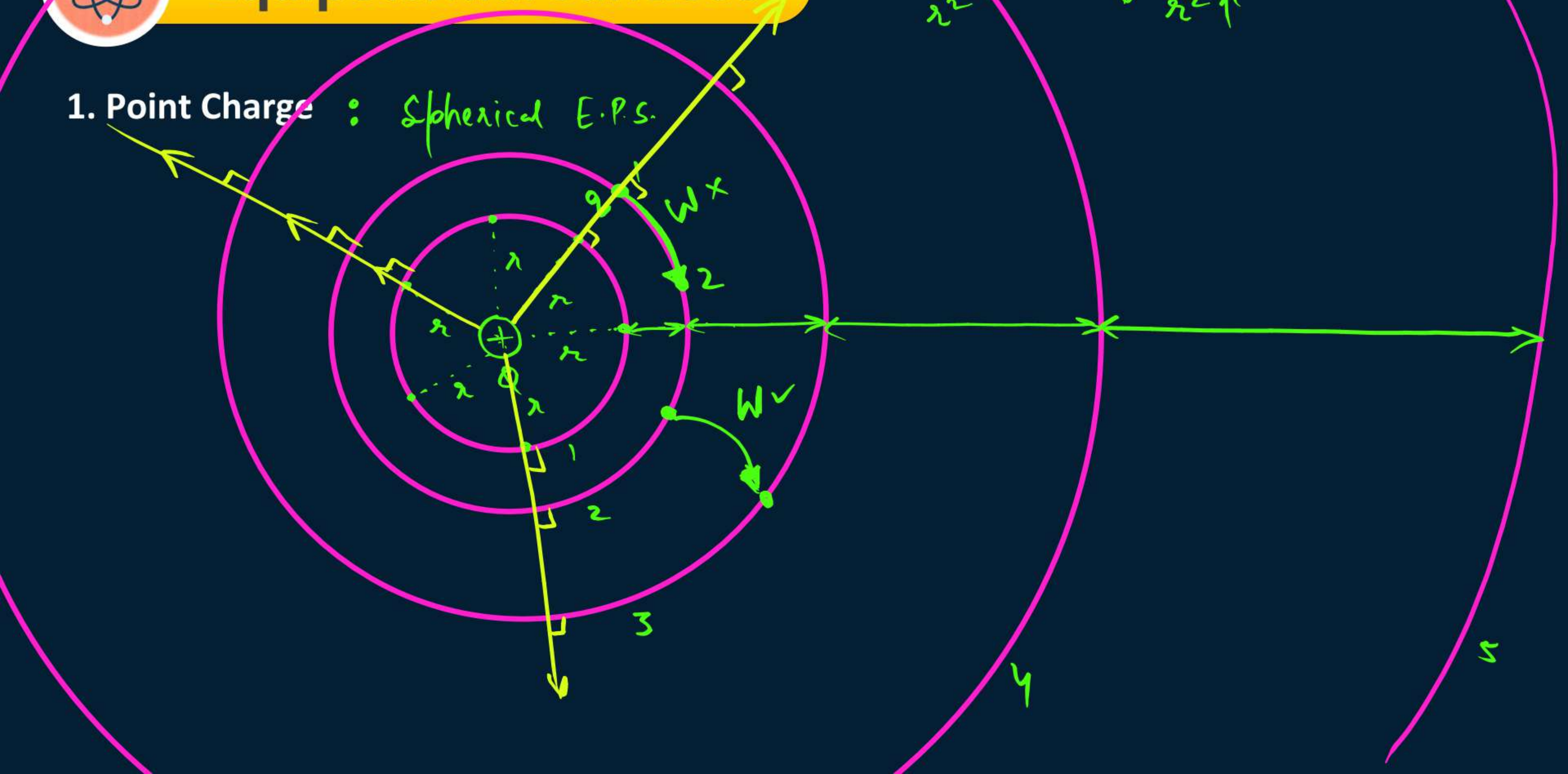
$\Delta V = 0$

$W = 0$

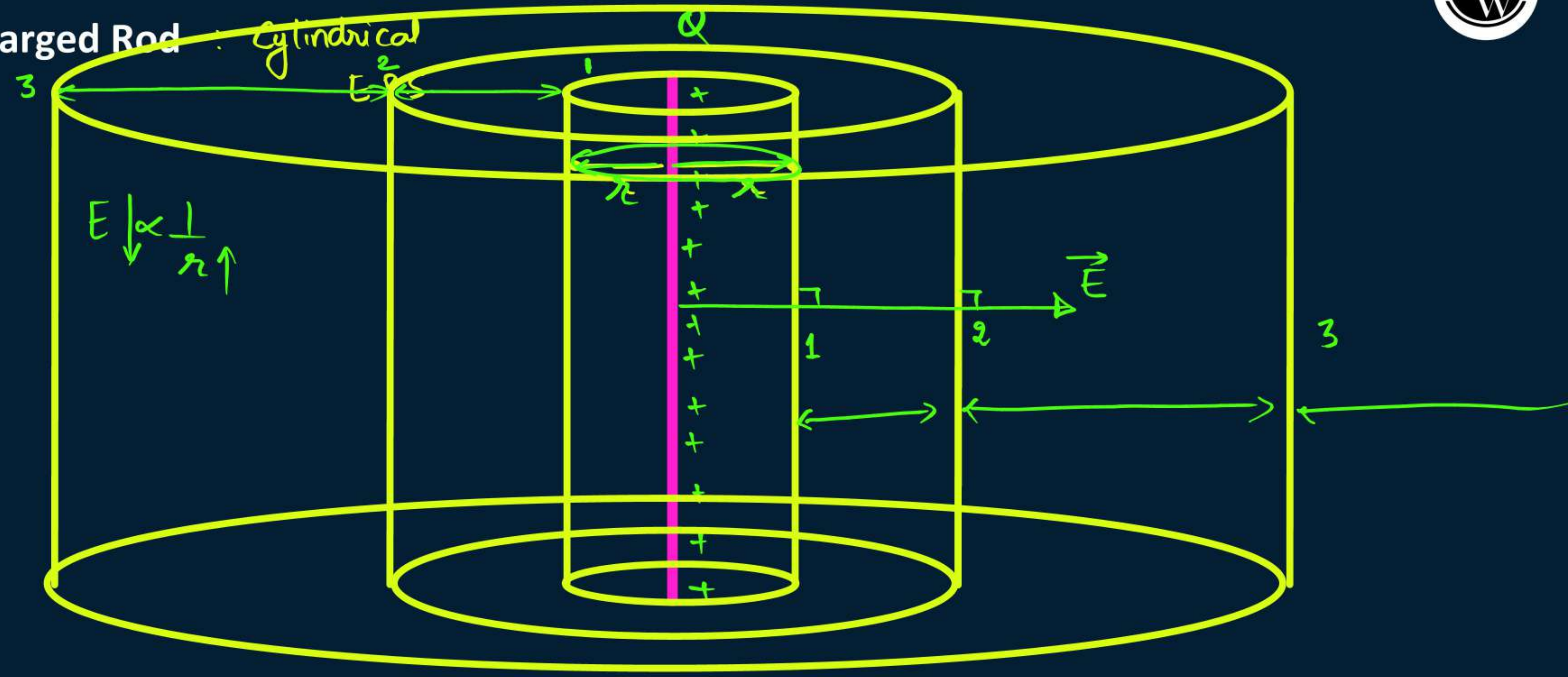
Equipotential Surfaces

$E = \frac{kQ}{r^2}$ or $E \propto \frac{1}{r^2}$

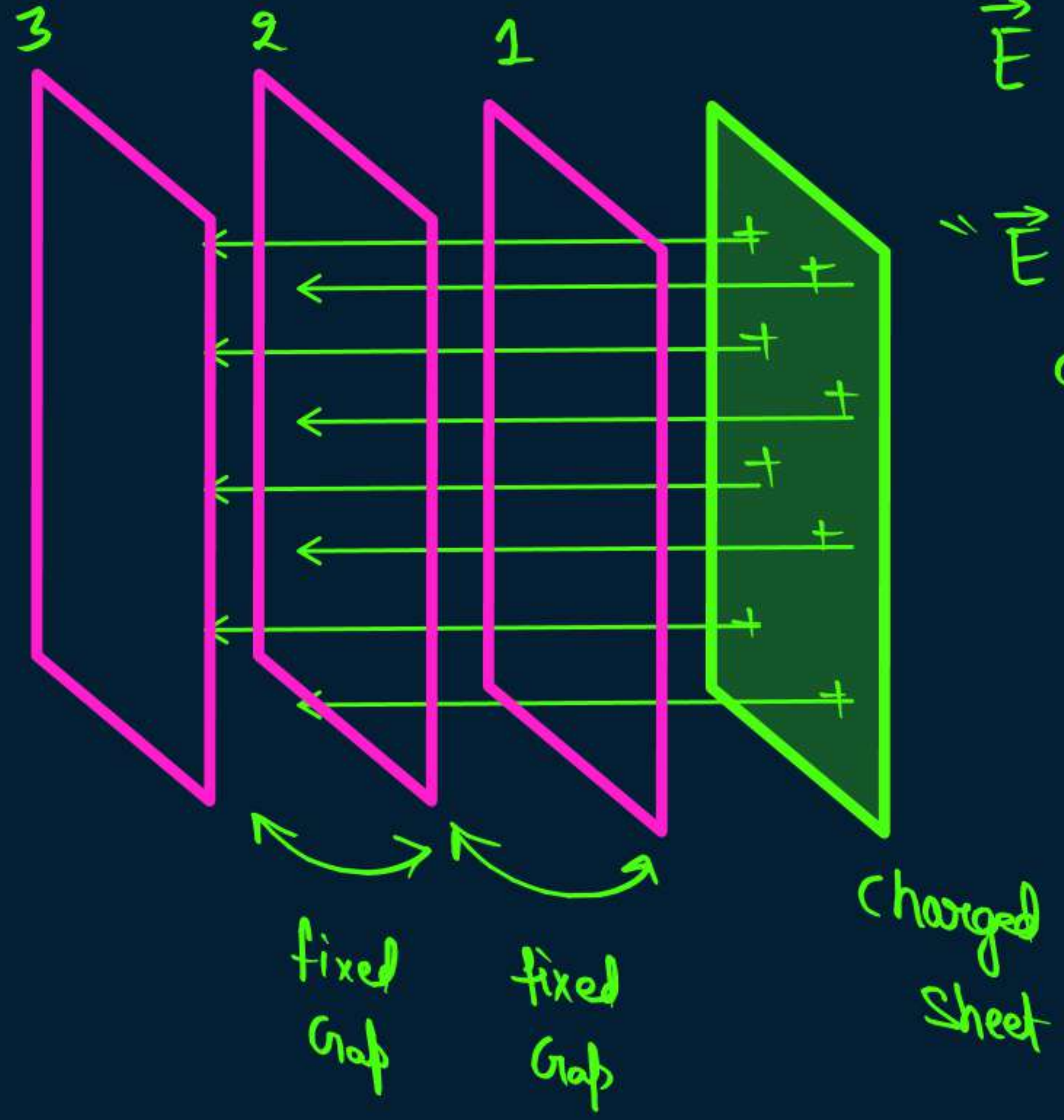
1. Point Charge : Spherical E.P.S.



2. Charged Rod : Cylindrical



3. Charged Sheet



$$\vec{E} = \frac{\sigma}{2\epsilon_0}$$

" $\vec{E}$ is constant "
does not vary with distance

QUESTION

H.W.

Draw three equipotential surfaces corresponding to a field that uniformly increases in magnitude but remains constant in Z-direction. How are these surfaces different from that of constant electric field along Z-direction.

[ALL India CBSE 2009]

QUESTION

H.W.

Charge q_2 is at the centre of a circular path with radius r. Work done in carrying charge q_1, once around this equipotential path, would be

(A) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}$

(B) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{2r}$

(C) Zero

(D) infinite

QUESTION

H.W.

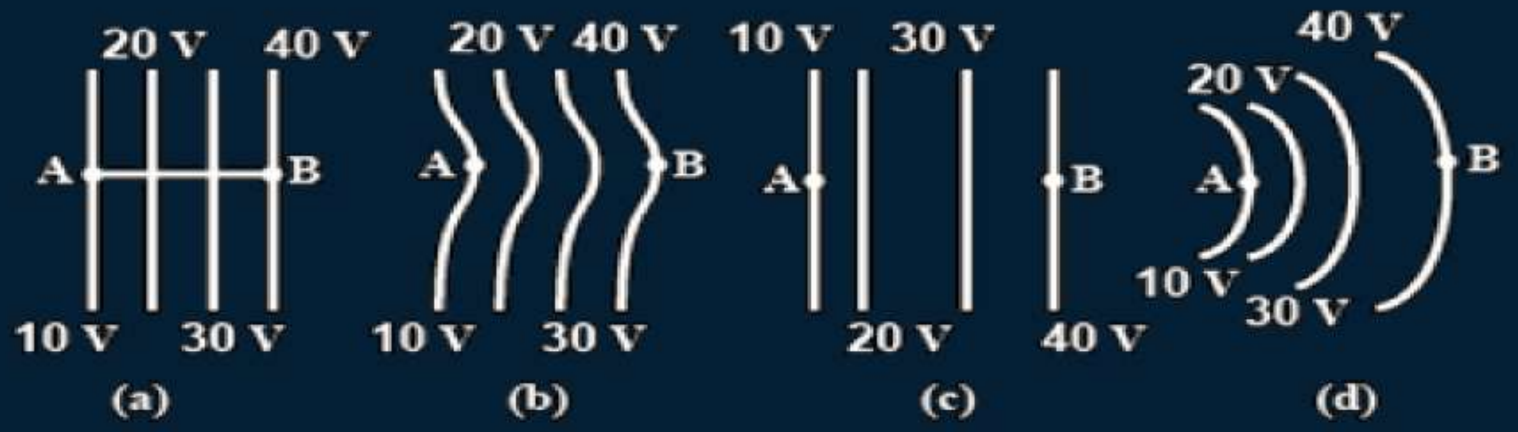
The diagrams below show regions of equipotential. A positive charge is moved from *A* to *B* in each diagram.

A Maximum work is required to move *q* in figure (c).

B In all the four cases the work done is the same.

C Minimum work is required to move *q* in figure (a).

D Maximum work is required to move *q* in figure (b).



QUESTION

H.W.

Shell

A hollow conducting sphere of radius R has a potential of 50 V at its surface. The potential at its inner point at a distance of $R/2$ from center is

A 50 V

B 100 V

C 25 V

D 75 V

Homework

Notes + Revision

H.W. in-class

DPP (Banega ✗ Try ✓)

PARISHRAM

2026

Lecture - 05

Electrostatic Potential and Capacitance

PHYSICS LECTURE-5

BY - RAKSHAK SIR

Topics *to be covered*

A Electric Dipole in Terms of Energy and Potential

B

C DIPOLE ✓

D Potential and Potential Energy in Dipole ✓

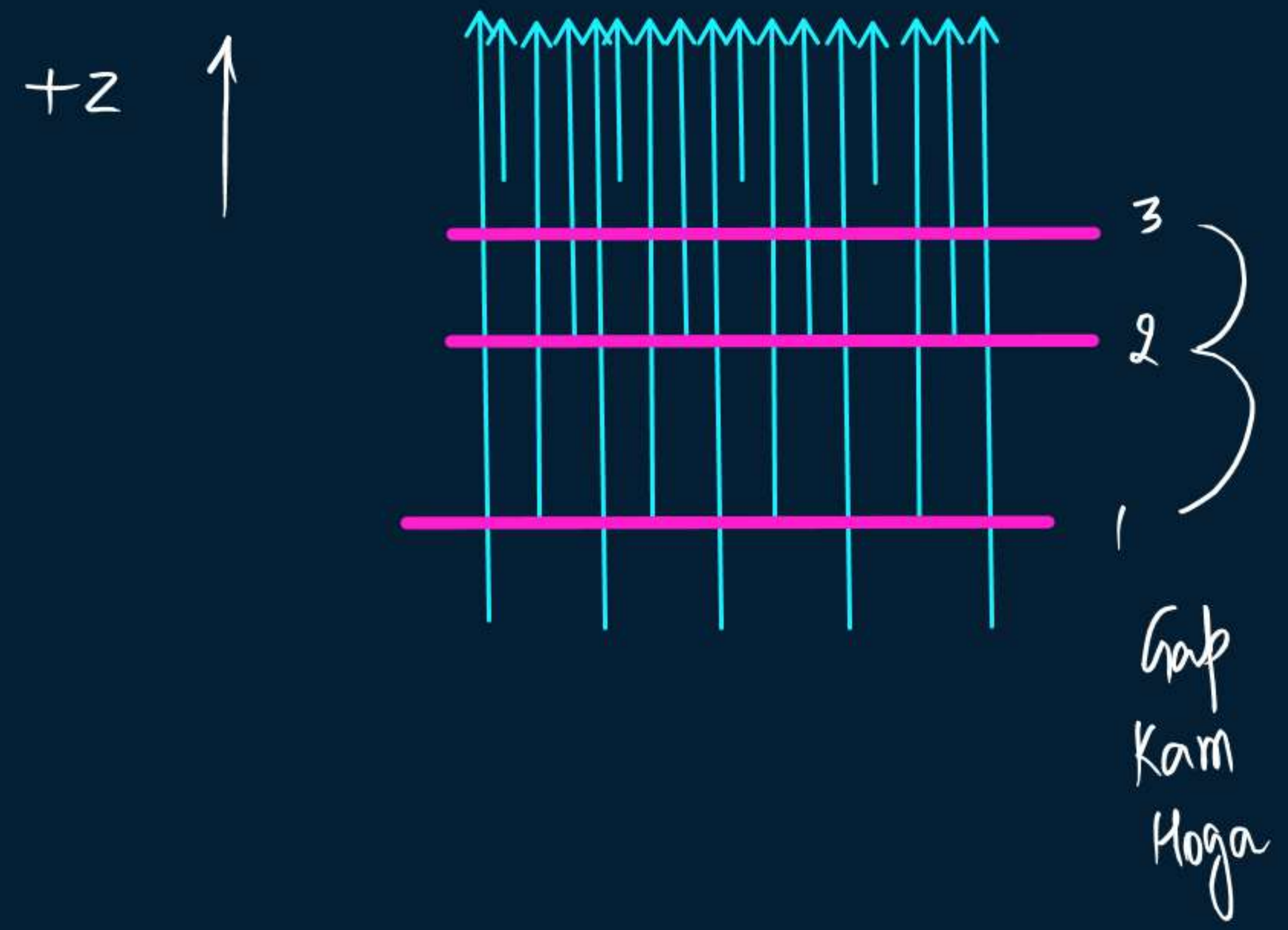
E

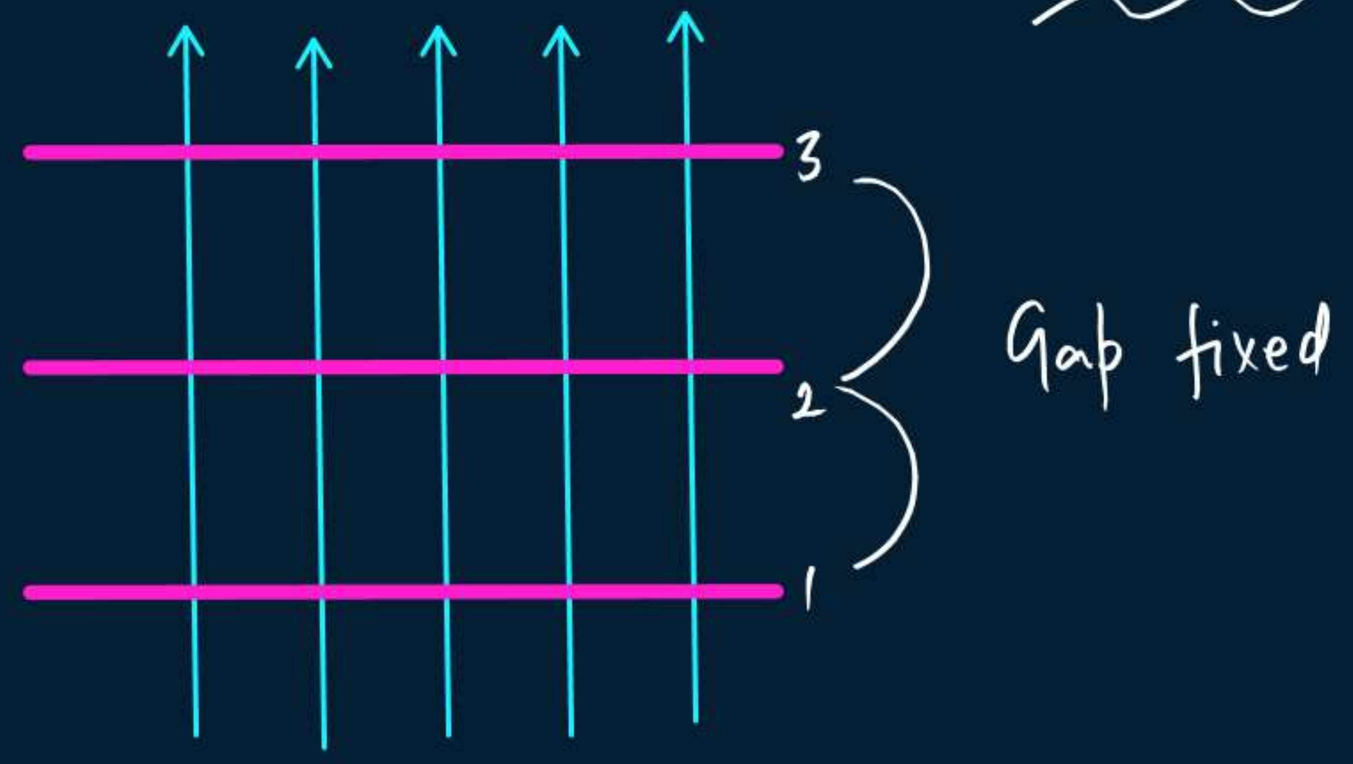
QUESTION

H.W.

Draw three equipotential surfaces corresponding to a field that $\boxed{\text{uniformly increases}}$ in magnitude but remains constant in Z-direction. How are these surfaces different from that of constant electric field along Z-direction.

[ALL India CBSE 2009]





QUESTION H.W.

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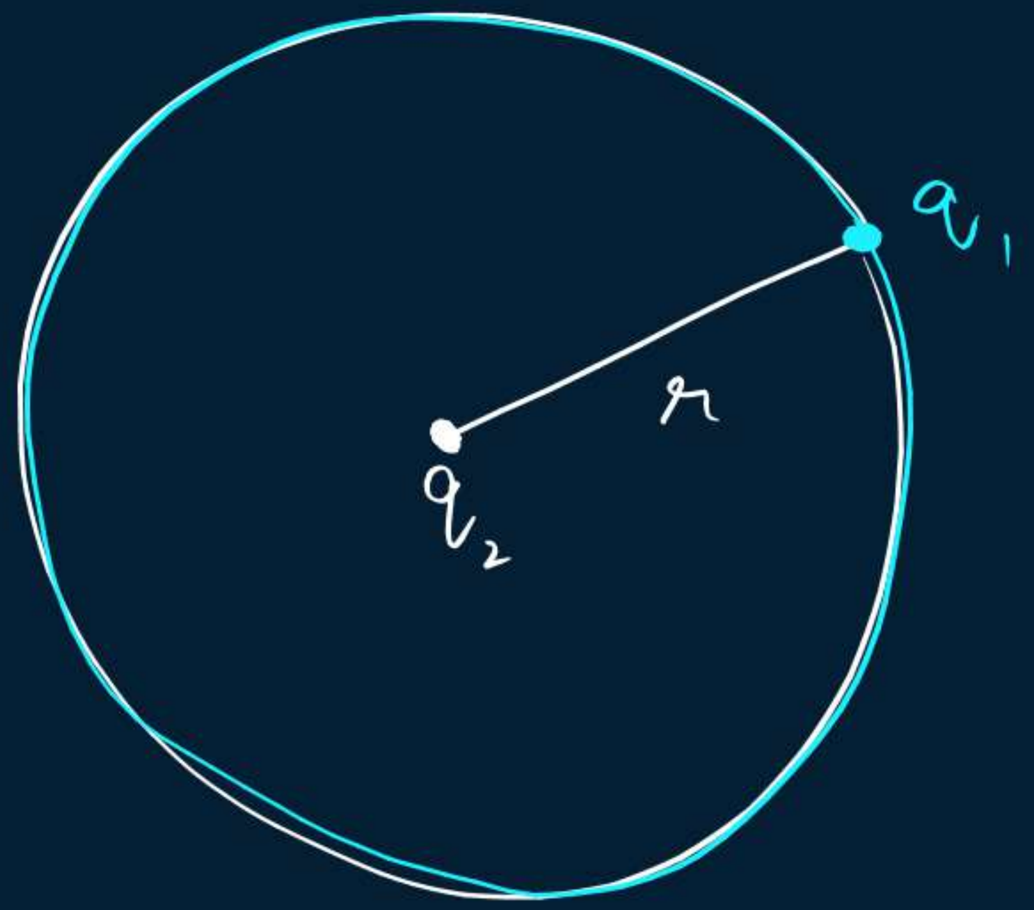
(B) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{2r}$

(C) Zero

(D) infinite



QUESTION

H.W.

NEET PYQ ~~Boards~~

The diagrams below show regions of equipotential. A positive charge is moved from *A* to *B* in each diagram.

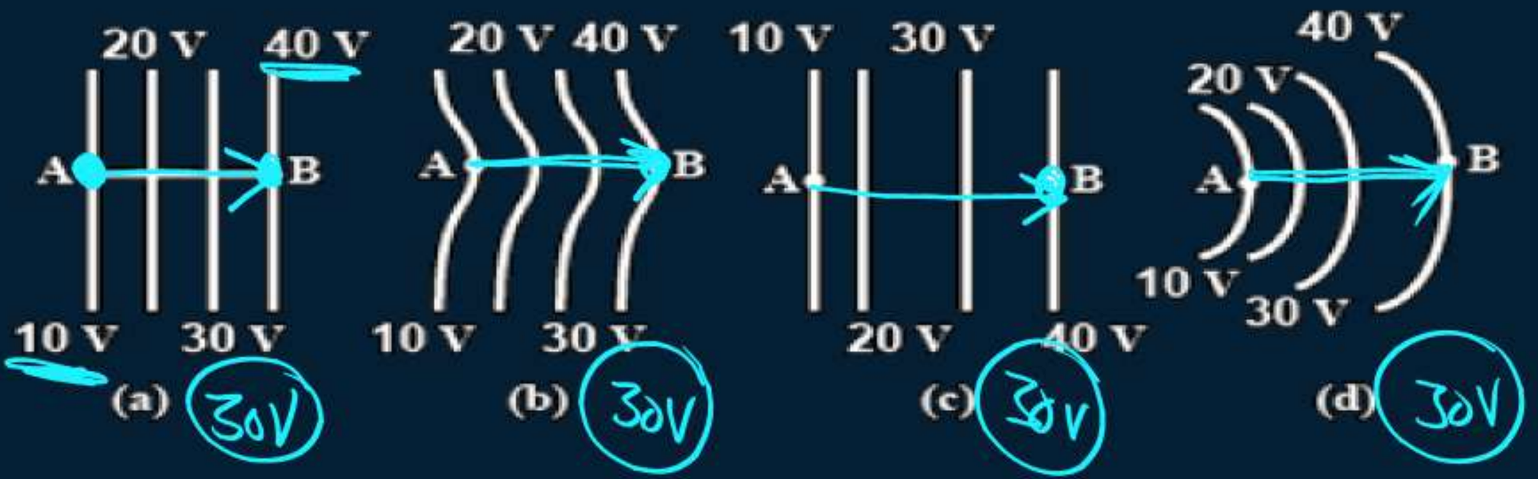
A. Maximum work is required to move *q* in figure (c).

B. In all the four cases the work done is the same.

C. Minimum work is required to move *q* in figure (a).

D. Maximum work is required to move *q* in figure (b).

$W = q(\Delta V)$



QUESTION

H.W.

shell

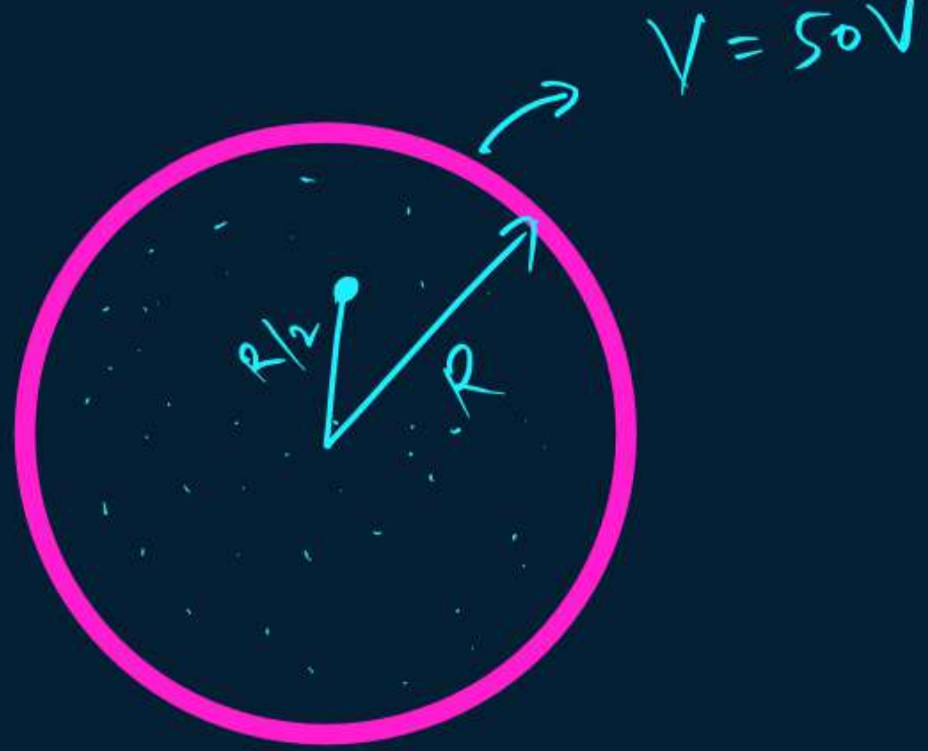
A hollow conducting sphere of radius R has a potential of 50 V at its surface. The potential at its inner point at a distance of $R/2$ from center is

(A) 50 V

(B) 100 V

(C) 25 V

(D) 75 V



$E = 0$

$-\frac{dV}{dr} = 0$

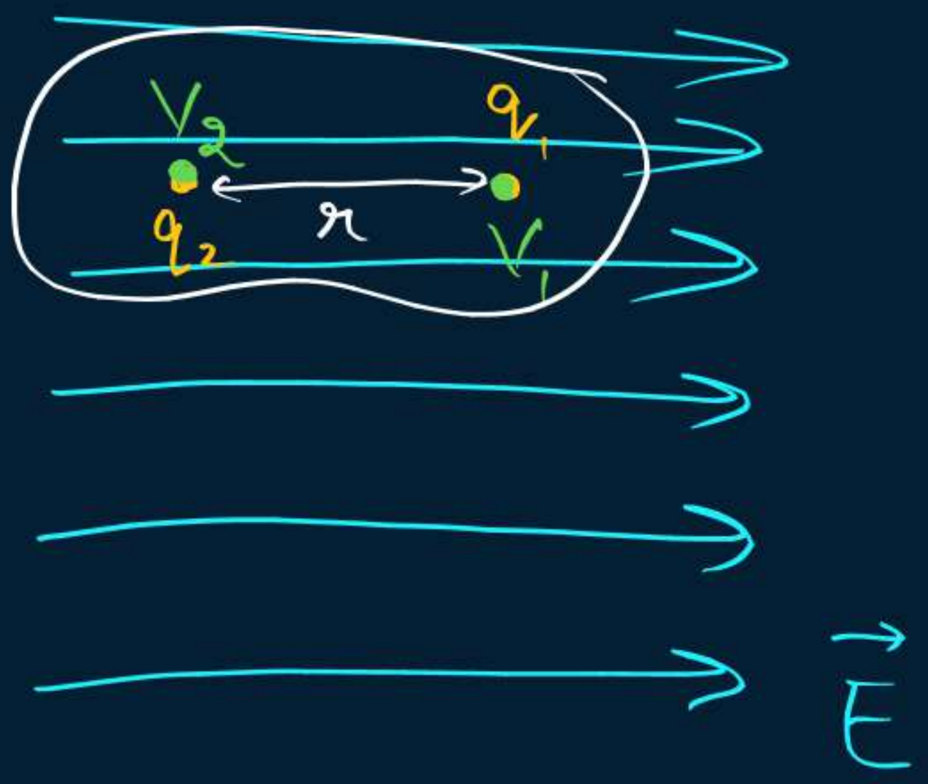
$V \Rightarrow \text{constant}$

$W = q(\Delta V)$

Potential Energy of Charges in External Field

Q find the Workdone in assembling the two charges in $\vec{E}_{ext}$.

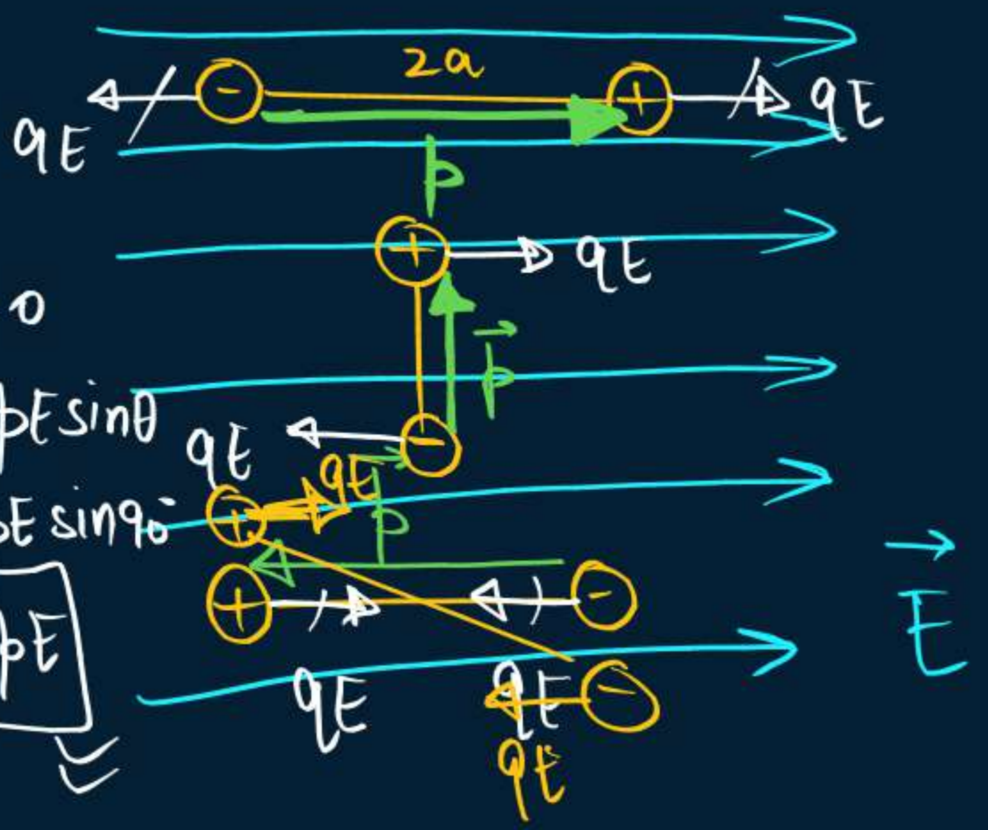
$$W_{ext} = \Delta U$$



$$\boxed{W_{ext} = U_{net} = q_1 V_1 + q_2 V_2 + \frac{K q_1 q_2}{r}}$$

Electric Dipole in External Uniform Electric Field

Y.K.B.



$F_{net} = 0$

$\tau_{net} = pE\sin\theta$

$= pE\sin 90°$

$\boxed{\tau_{Max} = pE}$

$$F_{net} = 0$$

$$\tau_{net} = \vec{p} \times \vec{E}$$

$$= pE\sin\theta$$

$$\tau_{net} = pE\sin 0° = 0$$

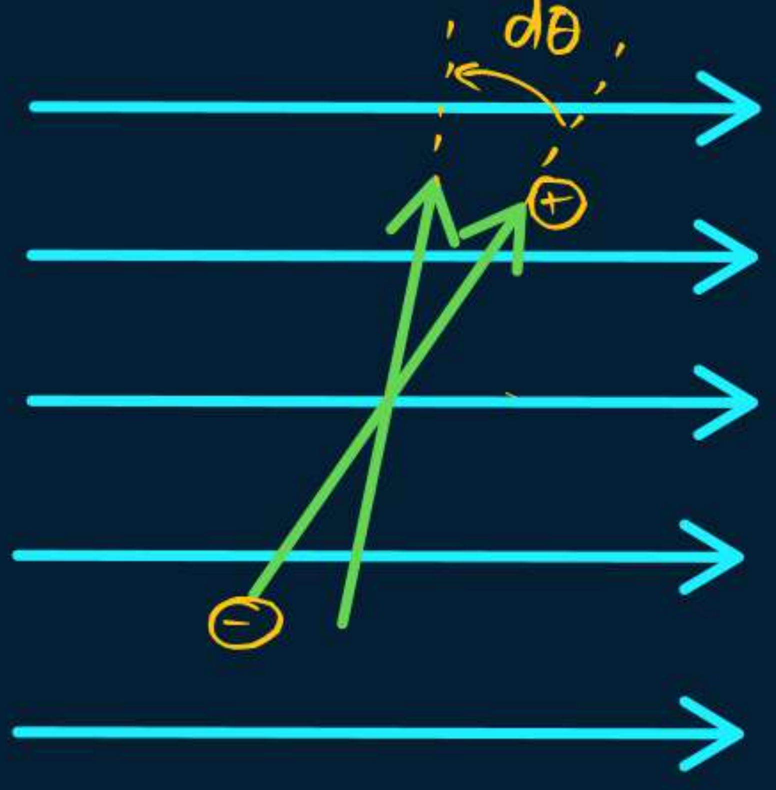
Stable eqⁿ $\Rightarrow$ U $\rightarrow$ Less

$$F_{net} = 0$$

$$\tau_{net} = pE\sin 180° = 0$$

Unstable eqⁿ $\Rightarrow$ U $\rightarrow$ More

Potential Energy of Dipole in external Electric Field



$$W_{ext} = \Delta U$$

$$W_{ext} = \int \vec{F}_{ext} \cdot d\vec{x}$$

$$W_{ext} = \int \vec{\tau}_{ext} \cdot d\vec{\theta}$$

$$W_{ext} = \int pE\sin\theta \cdot d\theta$$

$$W_{ext} = pE\int_{\theta_1}^{\theta_2} \sin\theta \cdot d\theta$$

$$W_{ext} = pE\left[-\cos\theta\right]_{\theta_1}^{\theta_2}$$

$$W_{ext} = pE\left[-\cos\theta_2 - (-\cos\theta_1)\right]$$

$$W_{ext} = pE\left[-\cos\theta_2 + \cos\theta_1\right]$$

जाप *

$$\boxed{\Delta U = pE\left[\cos\theta_1 - \cos\theta_2\right]}$$

θ_1 → Pehle Wallah Angle

θ_2 → Baad Wallah

Spl. case :-

$$\Delta U = pE[\cos\theta_1 - \cos\theta_2]$$

$$U_f - U_i = pE[\cos\theta_1 - \cos\theta_2]$$

let $\theta_1 = 90^\circ$, $U_i = 0$

then $\theta_2 = \theta$, $U_f = U$

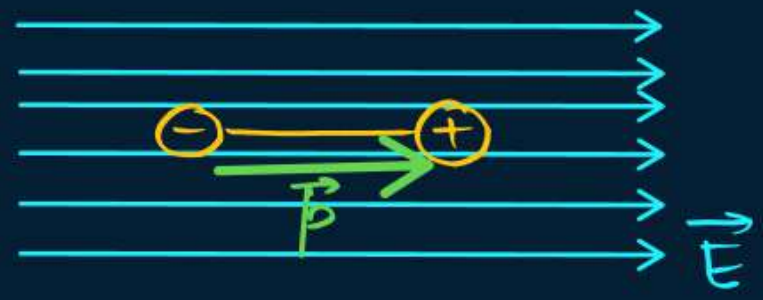
$$U - 0 = pE[\cos 90^\circ - \cos\theta]$$

$$U = pE(-\cos\theta)$$

$$\boxed{U = -\vec{p}\cdot\vec{E}}$$

RDx Feel : $U = -\vec{p}\cdot\vec{E} = -pE\cos\theta$

Stable Eql^n



$U = -pE\cos\theta$

$\theta = 0^\circ$

$U = -pE\cos 0^\circ$

$\boxed{U = -pE}$

↓

least : stable

UnStable Eql^n

$U = -pE\cos\theta$

$\theta = 180^\circ$

$= -pE\cos 180^\circ$

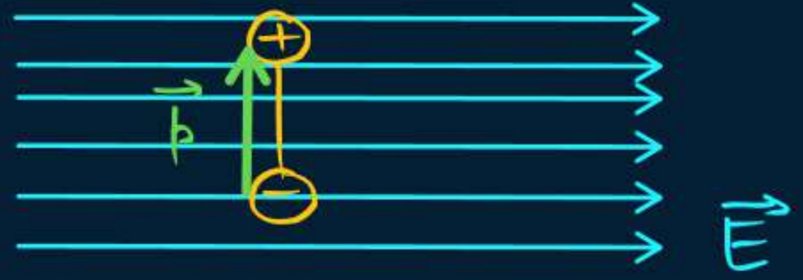
$= -pE(-1)$

$\boxed{U = +pE}$

↓

Most : Unstable

Neutral Eql^n



$U = -pE\cos\theta$

$\theta = 90^\circ$

$U = -pE\cos 90^\circ$

$\boxed{U = 0}$

↓

Beech Ki : Neutral

QUESTION

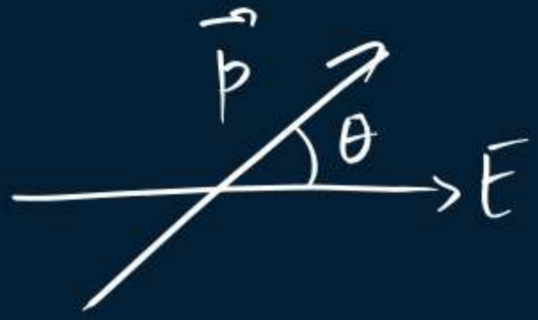
An electric dipole of moment p is placed in an electric field of intensity E. The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when $\theta = 90°$, the torque and the potential energy of the dipole will respectively be

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

$= pE\sin\theta$

$U = -\vec{p} \cdot \vec{E}$

$= -pE\cos\theta$



A $pE\sin\theta, -pE\cos\theta$

B $pE\sin\theta, -2pE\cos\theta$

C $pE\sin\theta, 2pE\cos\theta$

D $pE\cos\theta, -pE\sin\theta$

QUESTION

An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field. the force on it and its potential energy are respectively

zero

A $2\, q.E.$ and minimum

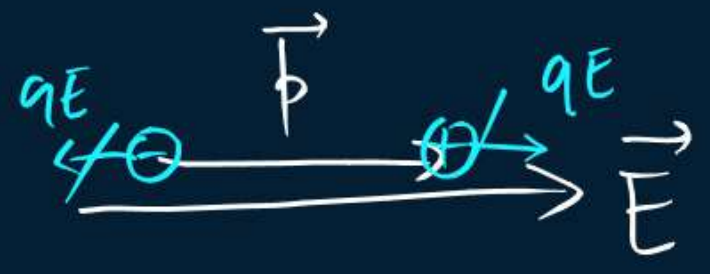
B $q.E$ and minimum

C zero and minimum

D $q.E.$ and maximum

$$U = -pE$$

minimum



QUESTION

An electric dipole of moment $\vec{p}$ is lying along a uniform electric field $\vec{E}$. The work done in rotating the dipole by 90° is

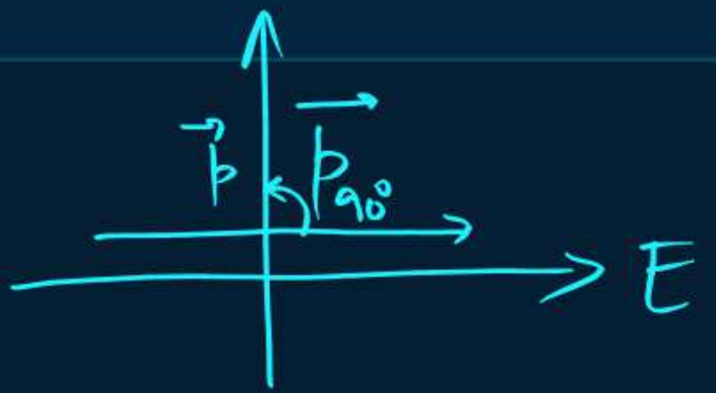
(A) pE

(B) $\sqrt{2}pE$

(C) $pE/2$

(D) $2pE$

$$\boxed{W_{ext} = \Delta U = pE\left[\cos\theta_1 - \cos\theta_2\right]}$$



$= pE[\cos 0° - \cos 90°]$

$= pE[1 - 0]$

$= pE$

$W_{ext} = \Delta U$

$= U_f - U_i$

$= 0 - (-pE)$

$= 0 + pE$

$W_{ext} = +pE$

$U_i = -pE\cos\theta$

$= -pE\cos 0°$

$= -pE$

$U_f = -pE\cos\theta$

$= -pE\cos 90°$

$= 0$

QUESTION

H.W.

Work done in moving dipole from stable equilibrium position to unstable position in electric field is

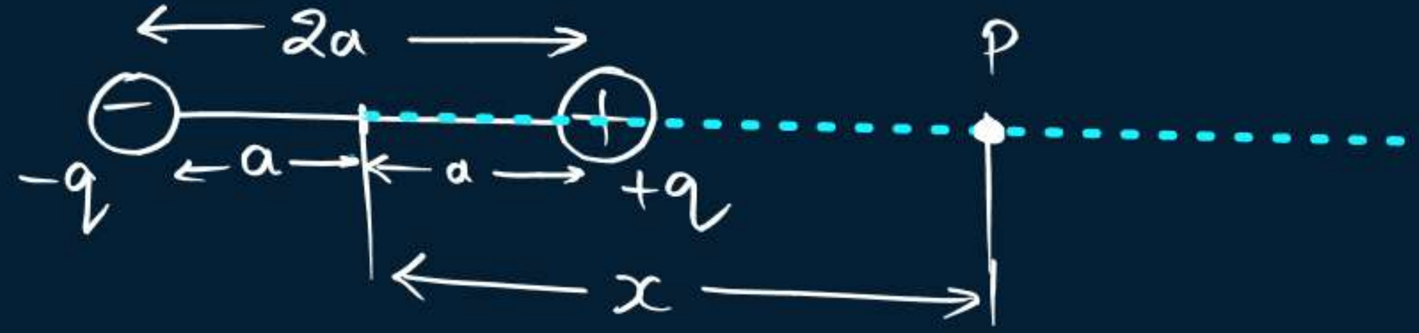
A pE

B $\sqrt{2}pE$

C $pE/2$

D $2pE$

Electric potential due to a dipole- 1. Axial Point



$$V_+ = \frac{Kq}{(x-a)}$$

$$V_- = \frac{-Kq}{(x+a)}$$

$$V_P^{net} = V_+ + V_-$$

$$= \frac{Kq}{(x-a)} - \frac{Kq}{(x+a)}$$

$$= Kq\left[\frac{1}{(x-a)} - \frac{1}{(x+a)}\right]$$

$$= Kq\left[\frac{x+a-(x-a)}{(x-a)(x+a)}\right]$$

$$= Kq\left[\frac{\cancel{x}+a-\cancel{x}+a}{x^2-a^2}\right] = \frac{Kq\,2a}{(x^2-a^2)}$$

$$\boxed{V_{axial} = \frac{kp}{(x^2-a^2)}}$$

Spl. Case :-

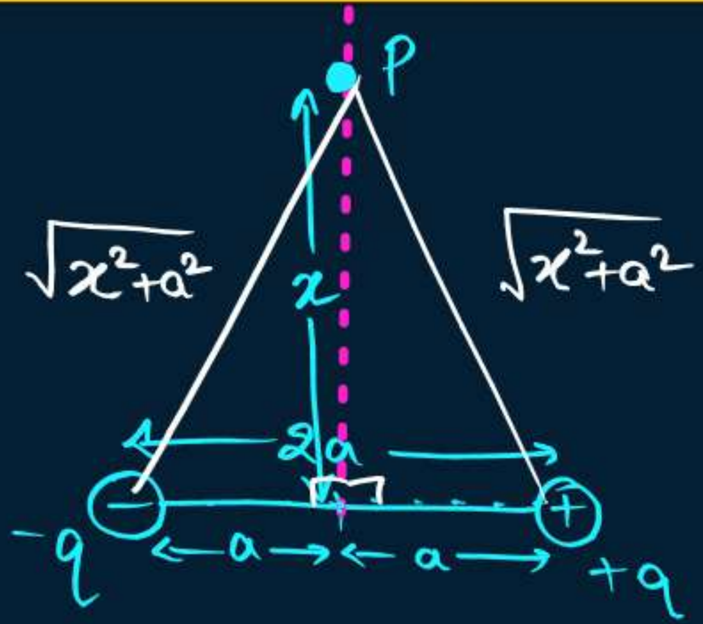
for a short dipole -

$$x >> a$$

$$x^2 - a^2 \approx x^2$$

$$\boxed{V_{axial} = \frac{kp}{x^2}}$$

Electric potential due to a dipole- 2. Equitorial Point



$$V_+ = \frac{Kq}{\sqrt{x^2+a^2}}$$

$$V_- = \frac{-Kq}{\sqrt{x^2+a^2}}$$

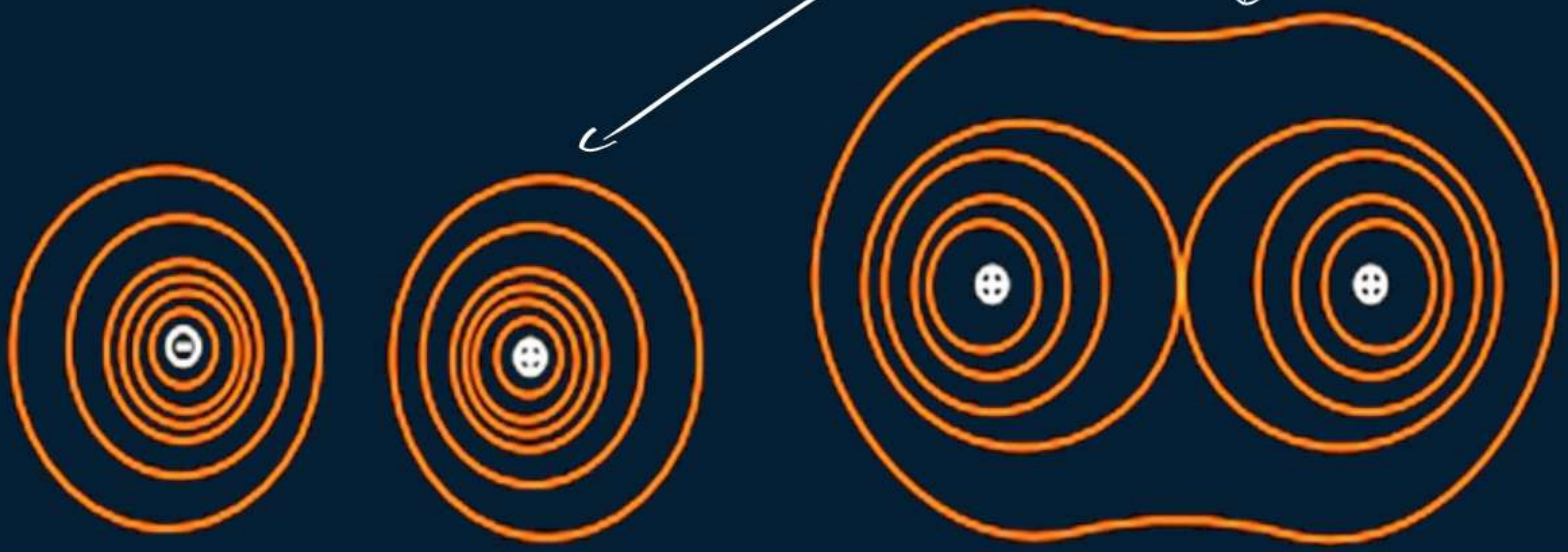
$$V_P^{eq} = V_+ + V_-$$

$$= \cancel{\frac{Kq}{\sqrt{x^2+a^2}}} - \cancel{\frac{Kq}{\sqrt{x^2+a^2}}} = 0$$

$$\boxed{V_{equi} = 0}$$

Equipotential Surfaces

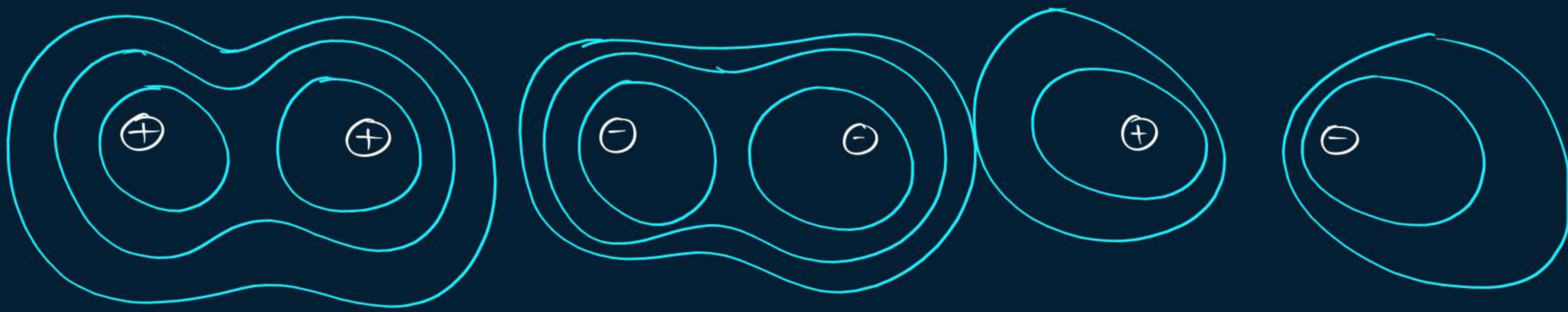
Dipole / Similar



(a) (b)

Some equipotential surfaces for (a) a dipole, (b) two identical positive charges.

RDx : Charges Repel : EPS Attract
Charges attract : EPS Repel



Homework

→ Notes ✓

→ H.W. ✓

→ DPP ✓

PARISHRAM

2026

Lecture - 06

Electrostatic Potential and Capacitance

PHYSICS LECTURE-6

BY - RAKSHAK SIR

Topics *to be covered*

- **A** Conductors ✓
- **B** Properties of Conductors ✓
- **C** Capacitance ✓
- **D**
- **E**

HW QUESTION

Work done in moving dipole from stable equilibrium position to unstable position in electric field is

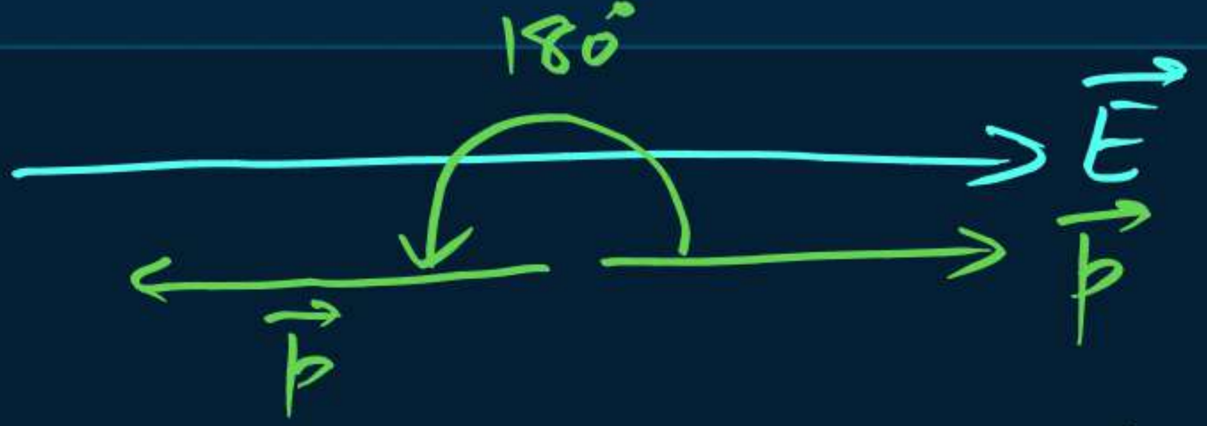
(A) pE

(B) $\sqrt{2}pE$

(C) $pE/2$

(D) $2pE$

$$W_{ext} = \Delta U$$
$$= U_f - U_i$$
$$= pE - (-pE)$$
$$= pE + pE$$
$$= 2pE \checkmark$$



$$U_f = -\vec{p}\cdot\vec{E}$$
$$= -pE\cos 180^\circ$$
$$= -pE(-1)$$
$$U_f = pE$$

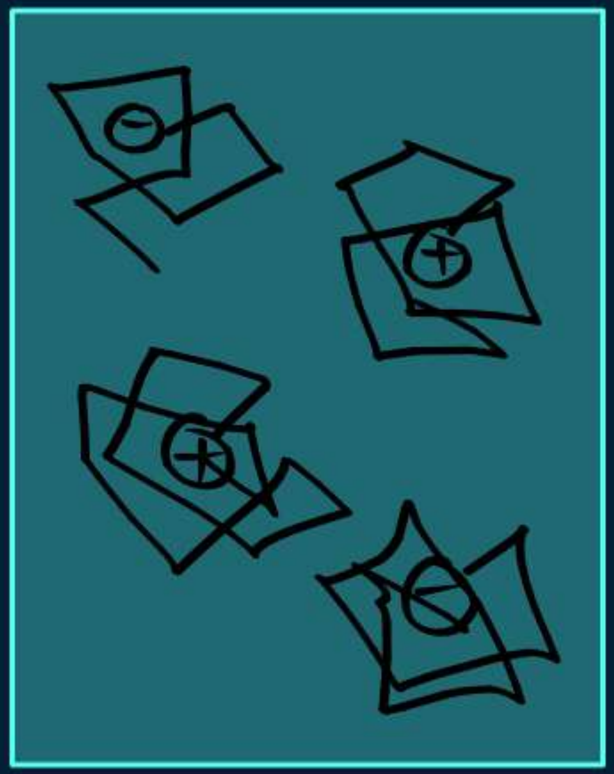
$$U_i = -\vec{p}\cdot\vec{E}$$
$$= -pE\cos 0^\circ$$
$$= -pE$$

Conductors

Conductors → Substances which allow free movement of charges.

eg- Silver, Gold, Copper, Iron, Al etc.

$E_{net} = 0$



Without $\vec{E}_{ext}$

(Random Motion of charges)
(Thermal)

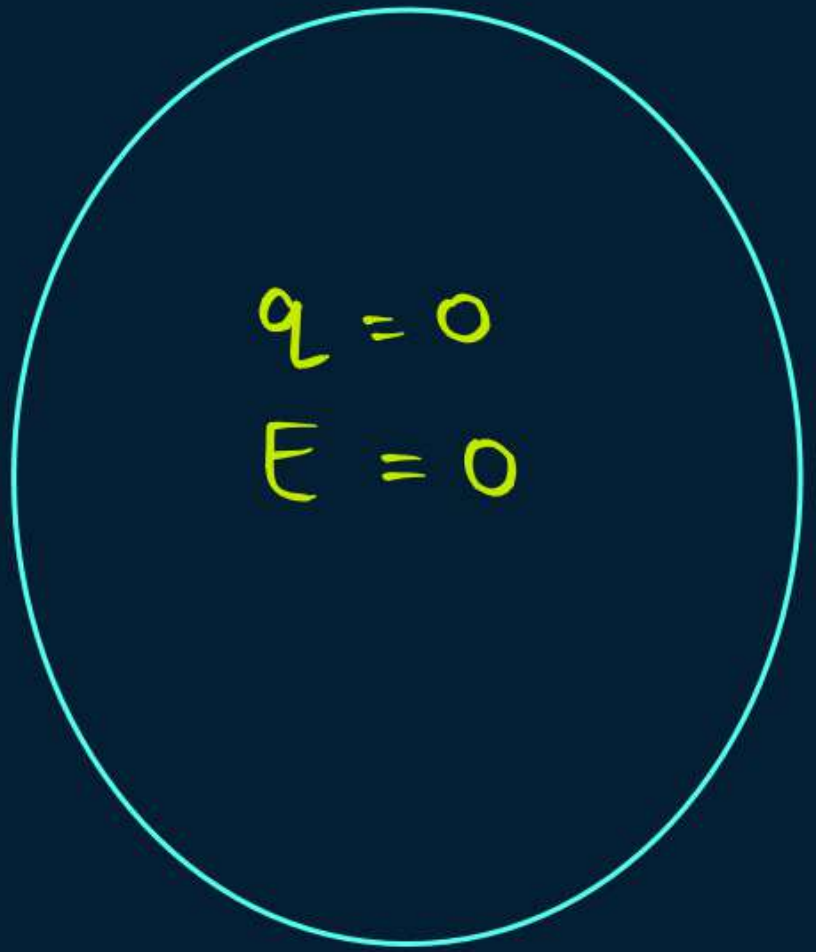
Applied $\vec{E}_{ext}$

(Polarisation → $E_{ind} = E_{ext} \rightarrow E_{net} = 0$)

* properties of conductors :-

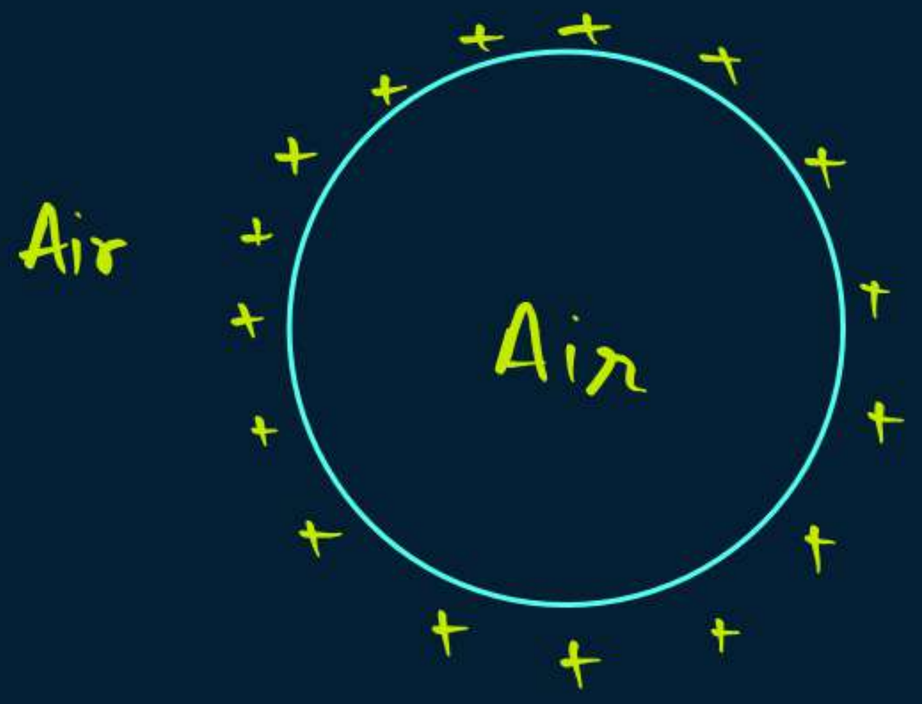
1. The electric field inside a conducting material of an isolated conductor is zero.

$E = 0$

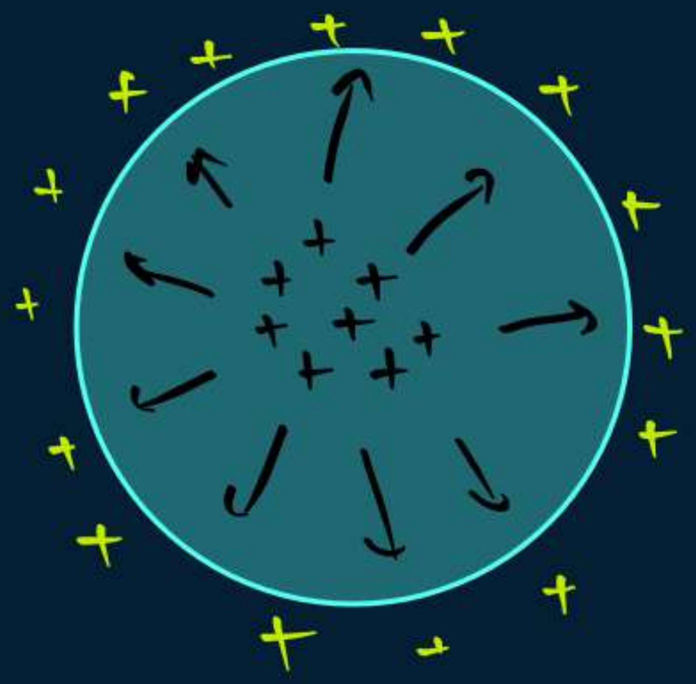


2. There is no excess charge inside a conductor. Any excess charge must $\boxed{\text{reside}}$ at the surface.

Home



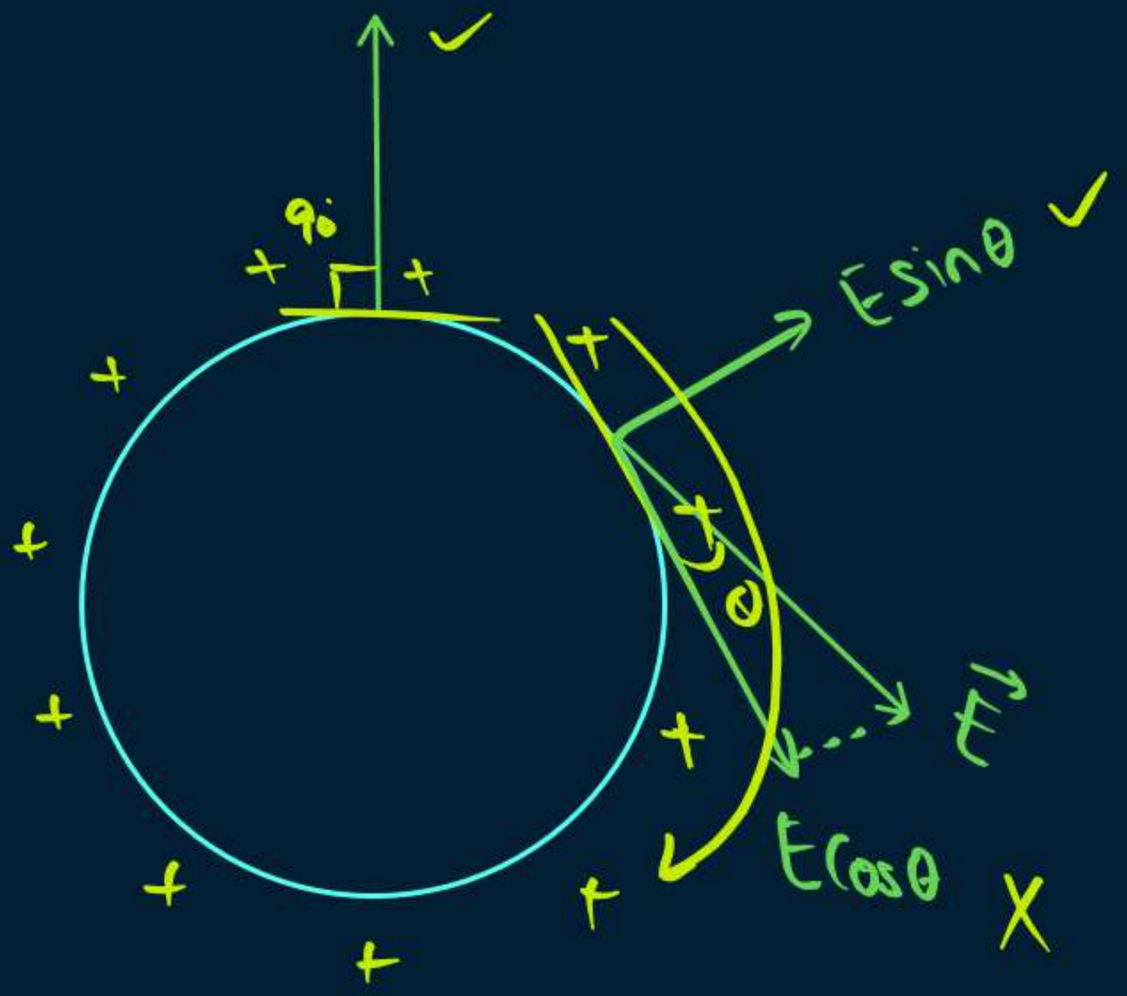
Hollow Conductor



Solid Conductor

3. **The electric field is always perpendicular (normal) to the surface of conductor.**

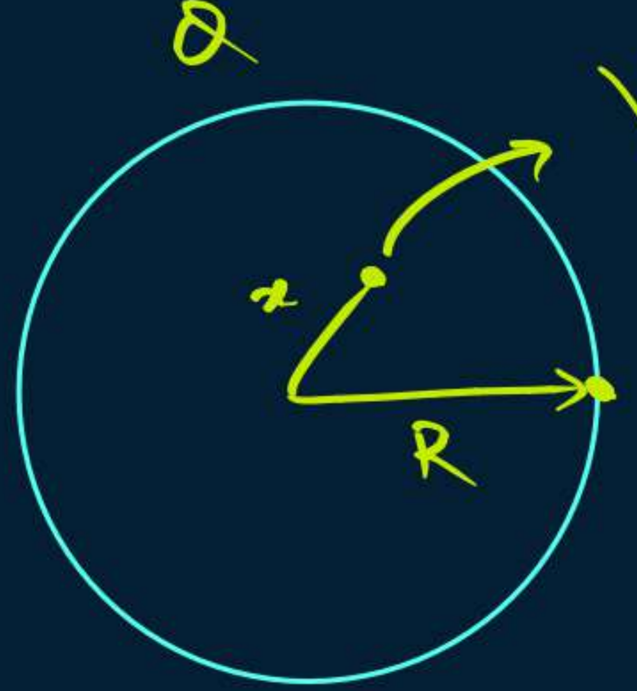
If E were not normal, it would have some non-zero component along the surface. Free charges on the surface of the conductor would then experience force and move. In the static situation, therefore, E should have no tangential component



V

4. Electrostatic potential is constant throughout the volume of the conductor and has the same value (as inside) on its surface

$$E = -\frac{dV}{dr}$$



$$V_{inside} = \frac{kQ}{R}$$

$$V_{surface} = \frac{kQ}{R}$$

As we know, $E_{inside} = 0$

$$0 = \frac{dV}{dr}$$

$V \Rightarrow$ Constant

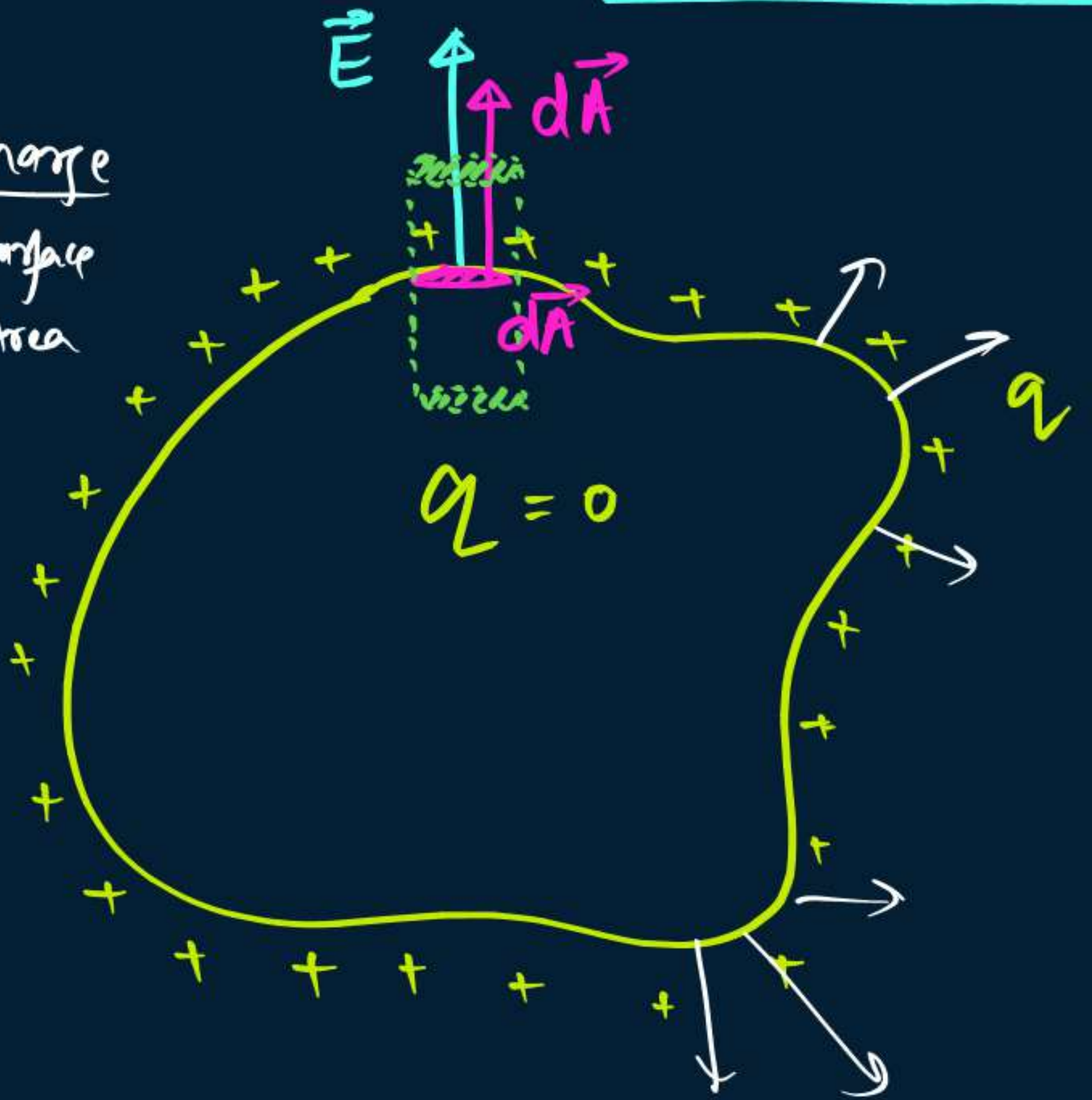
5. The electric field on the surface of conductor is $\frac{\sigma}{\epsilon_0}$, irrespective of the shape.

Y.K.B.

Surface charge density = $\frac{\text{Charge}}{\text{Surface Area}}$

$\sigma = \frac{q}{A}$

$q = \sigma A$



By using Gauss Law :-

$\phi_e = \oint \vec{E} \cdot d\vec{A} = E \oint dA = EA$ ---- (1)

$\phi_e = \frac{q_{enc}}{\epsilon_0} = \frac{\sigma A}{\epsilon_0}$ ---- (2)

eq. (1) and (11)

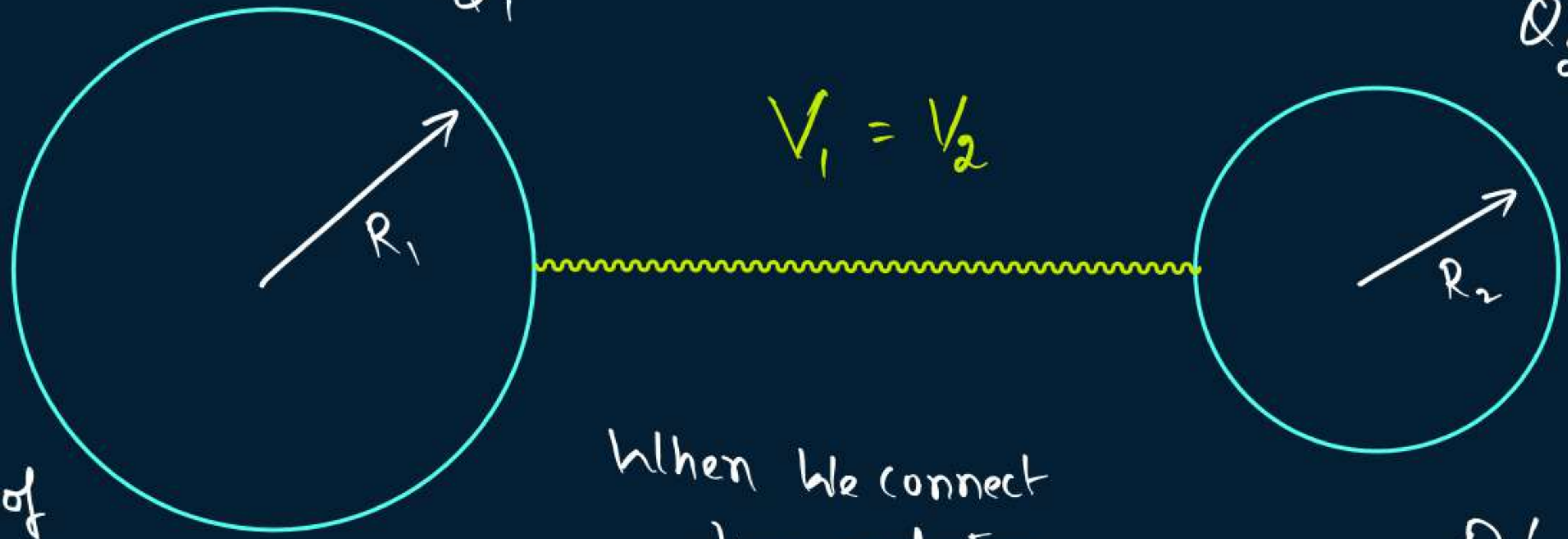
$E\cancel{A} = \frac{\sigma \cancel{A}}{\epsilon_0}$

$$\boxed{E = \frac{\sigma}{\epsilon_0}}$$

Connecting two conductors (at large distance)

$V_1 = \frac{kQ_1}{R_1}$ $\qquad$ $V_2 = \frac{kQ_2}{R_2}$

Q_1 $\qquad$ Q_2



$V_1 = V_2$

Q_1' $\qquad$ Q_2'

Law of
By conservation of charge

initial charge = final charge

$$\boxed{Q_1 + Q_2 = Q_1' + Q_2'}$$

When we connect two conductors

↓

Charge redistribution occurs

↓

they come at same potential

if Potential becomes same

$$V_1 = V_2$$

$$\frac{\cancel{K}Q_1}{R_1} = \frac{\cancel{K}Q_2}{R_2}$$

$$\frac{Q_1}{R_1} = \frac{Q_2}{R_2}$$

$$\frac{Q_1}{Q_2} = \frac{R_1}{R_2}$$

$$Q \uparrow \propto R \uparrow$$

#NOTE

#RDX

$$\boxed{Q_1' = \frac{Q_{net} R_1}{R_1 + R_2}} \quad \text{---- (i)}$$

$$\boxed{Q_2' = \frac{Q_{net} R_2}{R_1 + R_2}} \quad \text{---- (ii)}$$

Divide (i) by (ii)

$$\frac{Q_1' = \frac{\cancel{Q_{net}} R_1}{\cancel{R_1 + R_2}}}{Q_2' = \frac{\cancel{Q_{net}} R_2}{\cancel{R_1 + R_2}}} \Rightarrow \boxed{\frac{Q_1'}{Q_2'} = \frac{R_1}{R_2}}$$

$$\{Q \uparrow \propto R \uparrow\}$$

$$\boxed{\sigma = \frac{Q}{A}}$$

$$\sigma_1' = \frac{Q_1'}{4\pi R_1^2} \quad \cdots\cdots (I)$$

$$\sigma_2' = \frac{Q_2'}{4\pi R_2^2} \quad \cdots\cdots (II)$$

Divide (I) by (II)

$$\frac{\sigma_1'}{\sigma_2'} = \frac{\dfrac{Q_1'}{\cancel{4\pi} R_1^2}}{\dfrac{Q_2'}{\cancel{4\pi} R_2^2}} = \left(\frac{Q_1'}{Q_2'}\right)\frac{R_2^2}{R_1^2}$$

$$\frac{\sigma_1'}{\sigma_2'} = \left(\frac{\cancel{R_1}}{\cancel{R_2}}\right) \times \frac{R_2^{\cancel{2}}}{R_1^{\cancel{2}}}$$

$$\boxed{\frac{\sigma_1'}{\sigma_2'} = \frac{R_2}{R_1}}$$

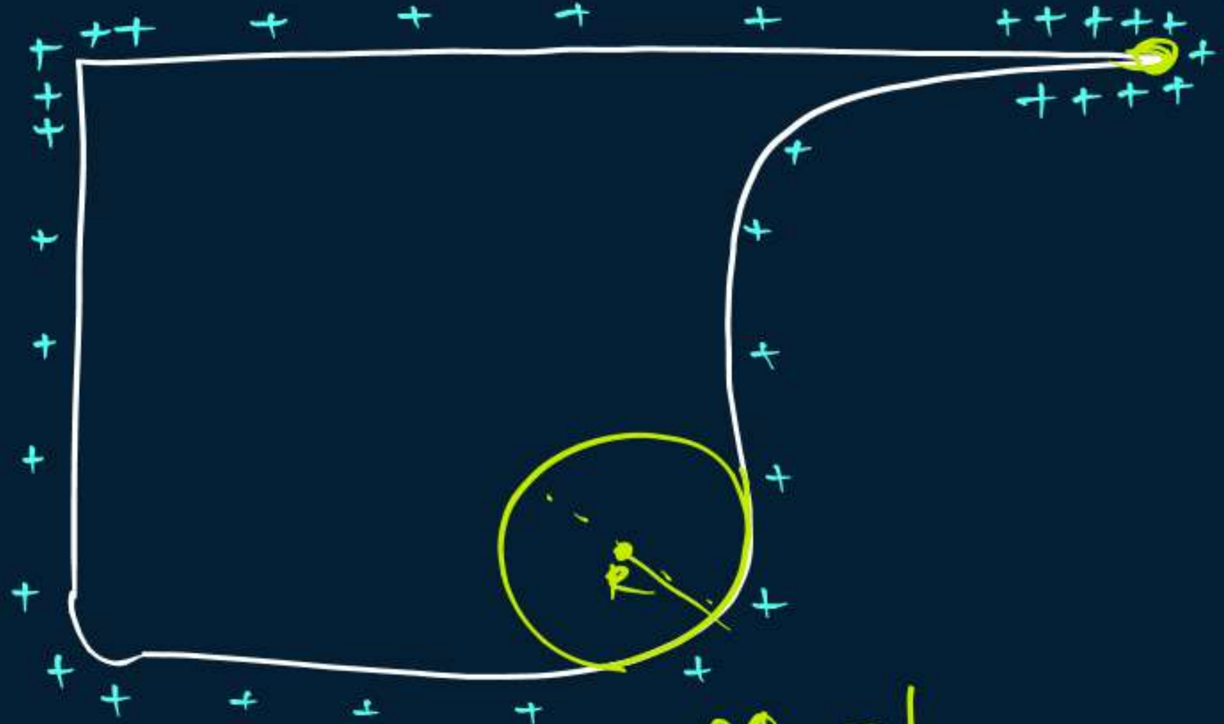
$$\sigma \propto \frac{1}{R}$$

Surface charge density is more where radius is less
(Sharp edges)

Surface charge density is less where radius is more
(Blunt edges)

$R\downarrow \; \sigma\uparrow$

$\sigma\uparrow \propto \dfrac{1}{R\downarrow}$



$R\uparrow \; \sigma\downarrow$

QUESTION

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

Two charged spherical conductors of radii R_1 and R_2 are connected by a wire. Then, the ratio of surface charge densities of the spheres (σ_1/σ_2) is

A $\frac{R_1}{R_2}$

B $\frac{R_2}{R_1}$

C $\sqrt{\frac{R_1}{R_2}}$

D $\frac{R_1^2}{R_2^2}$

$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$

QUESTION

$Q\uparrow \propto R\uparrow$

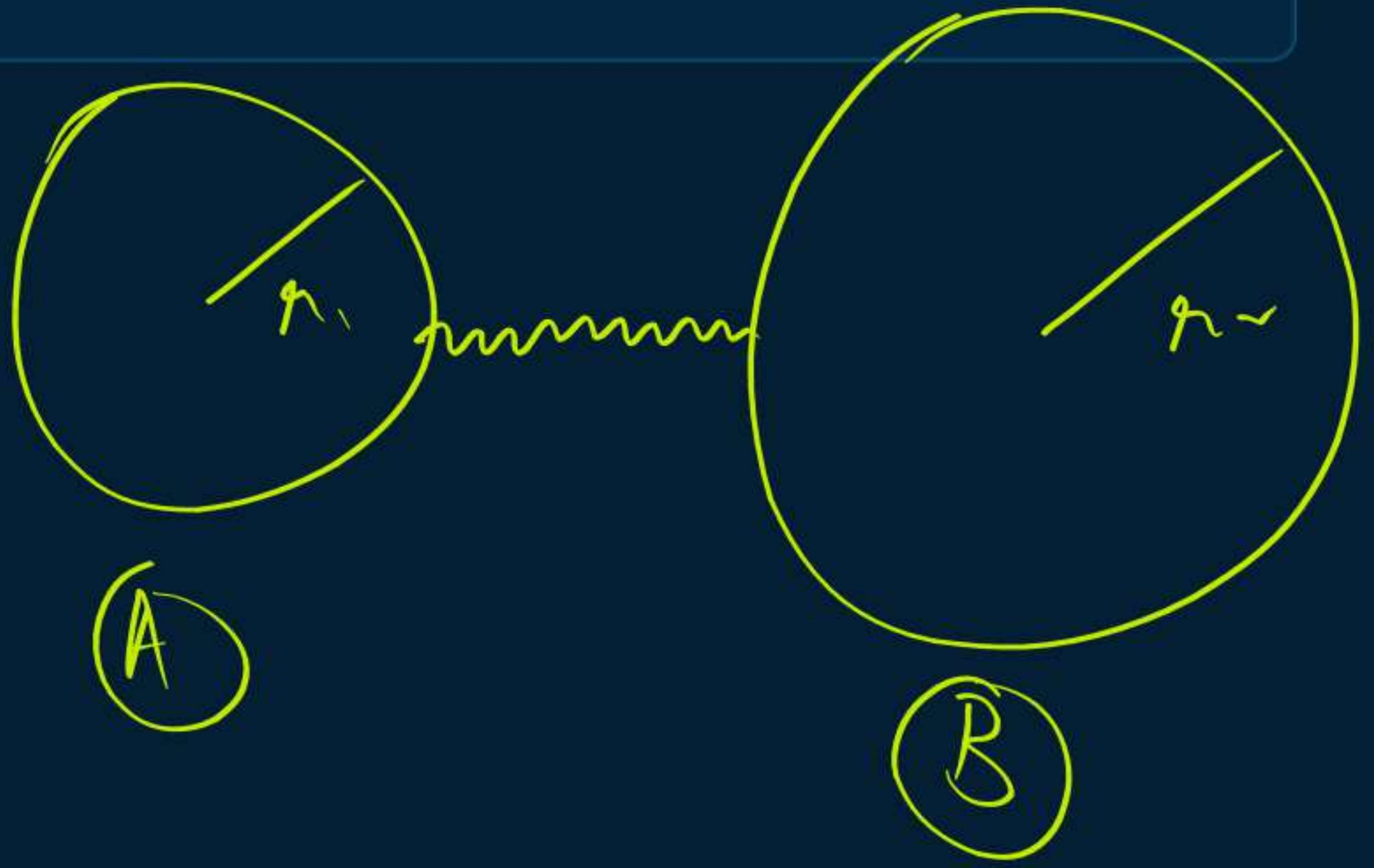
The radius of two metallic spheres A and B are r_1 and r_2 respectively ($r_2 > r_1$). They are connected by a thin wire and the system is given a certain charge. The charge will be greater

A. On the surface of the sphere B

B. On the surface of the sphere A

C. Equal on both

D. Zero on both



QUESTION

Two metallic spheres of radii 1 cm and 2 cm are given charges 10^{-2} C and 5×10^{-2} C respectively. If they are connected by a conducting wire, the final charge on the smaller sphere is

(A) 3×10^{-2} C

(B) 4×10^{-2} C

(C) 1×10^{-2} C

(D) 2×10^{-2} C

$Q_2' = ?$

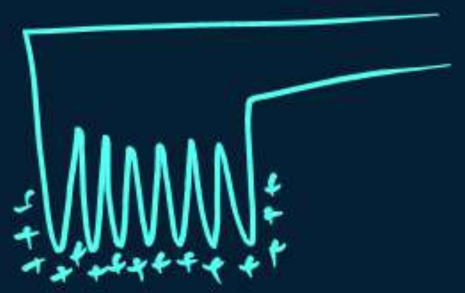
$$Q_2' = \frac{Q_{net}\, r_2}{r_1 + r_2}$$

$$= \frac{(10^{-2} + 5\times10^{-2}) \times 1\,\text{cm}}{1\,\text{cm} + 2\,\text{cm}} = \frac{10^{-2}(\cancel{6}^{\,2})}{\cancel{3}}$$

$\boxed{Q_2' = 2\times10^{-2}\,C}$

6. **The surface charge density (σ) is inversely proportional to the radius of curvature (r) of conductor.**

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



QUESTION

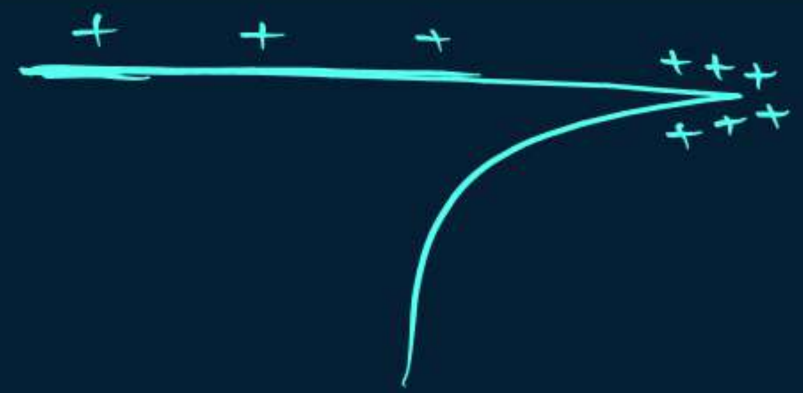
How does the charge densities of conductors vary on an irregularly shaped conductor?

A High at sharp and less at flat portion

B Less at sharp and high at flat portion

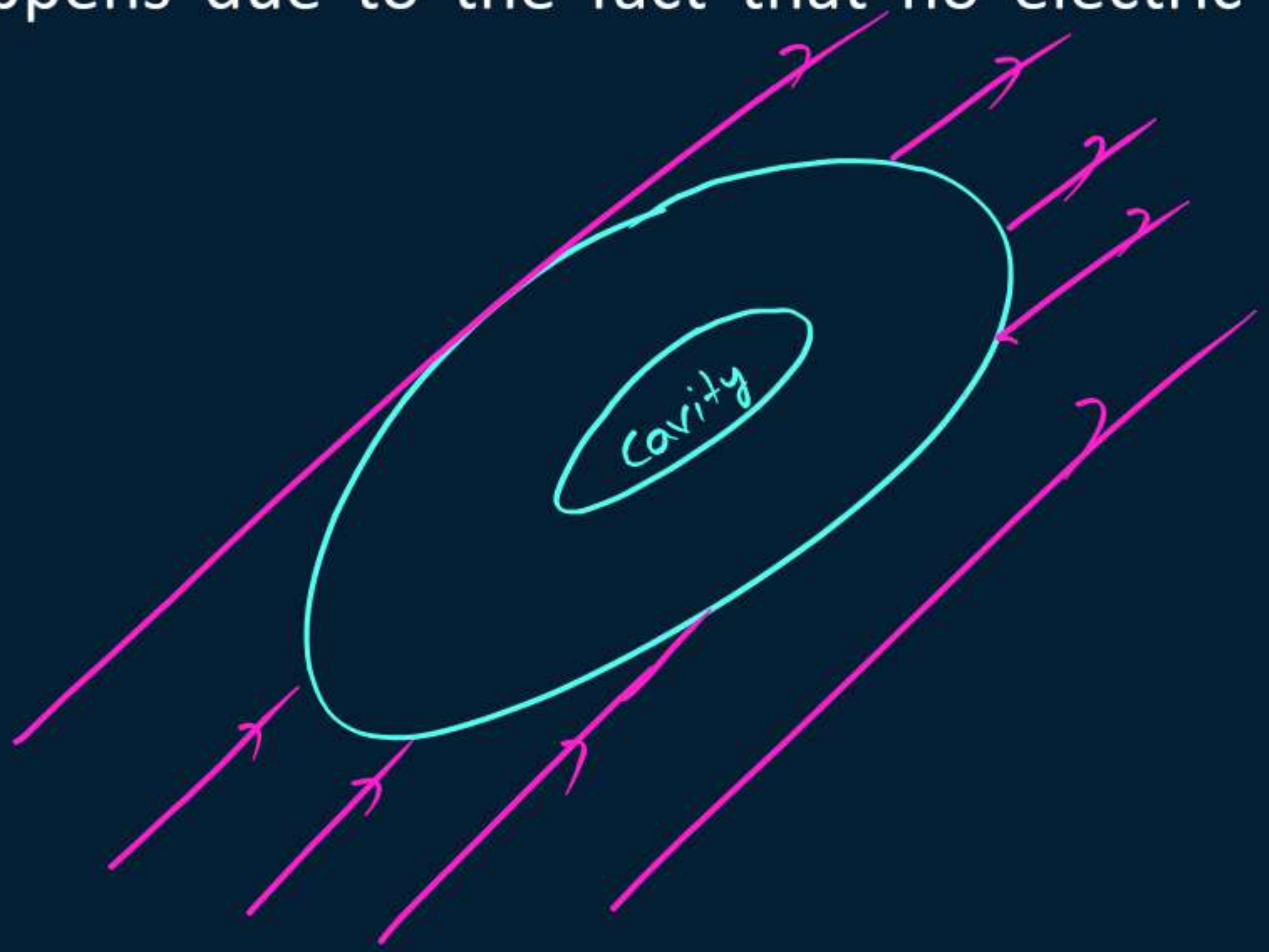
C Remains constant

D Zero at sharp and high at flat portion



Electrostatic Shielding

The process involves the making a region free from any electric field is called electrostatic shielding. It happens due to the fact that no electric field exist inside a charged hollow conductor.



Consider a conductor with a cavity, with no charges inside the cavity. A remarkable result is that the electric field inside the cavity is zero, whatever be the size and shape of the cavity and whatever be the charge on the conductor and the external fields in which it might be placed.

Whatever be the charge and field configuration outside, any cavity in a conductor remains shielded from outside electric influence: the field inside the cavity is always zero. This is known as electrostatic shielding.

During lightning, it is advisable to stay inside a car than under a tree, because car is a conductor and no electric field or lightning can enter inside it.

Homework

Notes ✓

DPP ✓

Revision ✓

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2026

Lecture - 07

Electrostatic Potential and Capacitance

PHYSICS LECTURE-7

BY - RAKSHAK SIR

Topics *to be covered*

- **A** Capacitance ✓
- **B** Energy Stored in a Capacitor ✓
- **C**
- **D**
- **E**

Capacitors

- Device used to store charge (or Electric Energy)

denoted by 'C'.

- Scalar ✓

- Also Called Condensers

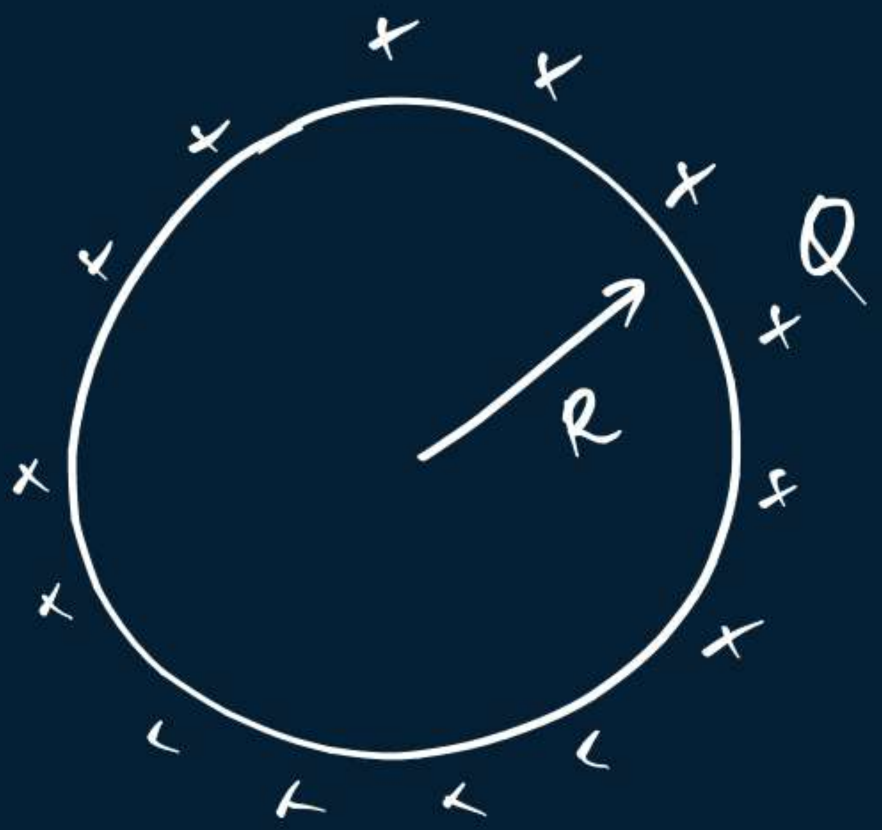
- SI - Farad (F) but a very large unit, ✓ 1 Farad or 1F

  there are smaller units also -

$$1\,nF = 10^{-9}\,F \qquad 1\,\mu F = 10^{-6}\,F$$

$$1\,pF = 10^{-12}\,F$$

Capacitor



$$V = \frac{kQ}{R}$$

$$V \propto Q$$

$$Q \propto V$$

$$\boxed{Q = CV}$$

Charge

Capacitance (constant)

Voltage

$$* \ \boxed{C = \frac{Q}{V}}$$

* $\boxed{C = \frac{Q}{V}} = \frac{\cancel{2}Q}{\cancel{2}V}$ if V is increased to $2V$ then C becomes C

Constant $= \frac{\cancel{5}Q}{\cancel{5}V}$

$\left.Q \propto V\right\}$ True

$\left.\begin{array}{l} C \propto Q \\ C \propto \frac{1}{V} \end{array}\right\}$ False

*NOTE :-

C does not depend on Q or V, if we increase V, Q will also increase with same factor

Units and Dimensions

SI : Farad

: $1\,nF = 10^{-9}\,F$

$1\,\mu F = 10^{-6}\,F$

$1\,pF = 10^{-12}\,F$

$$Q = CV$$

$$C = \frac{Q}{V}$$

$$C = \frac{[AT]}{[ML^2T^{-3}A^{-1}]}$$

$$[C] = [M^{-1}L^{-2}T^4A^2]$$

Y.K.B.

$$I = \frac{Q}{t}$$

$$[A] = \frac{[Q]}{[T]}$$

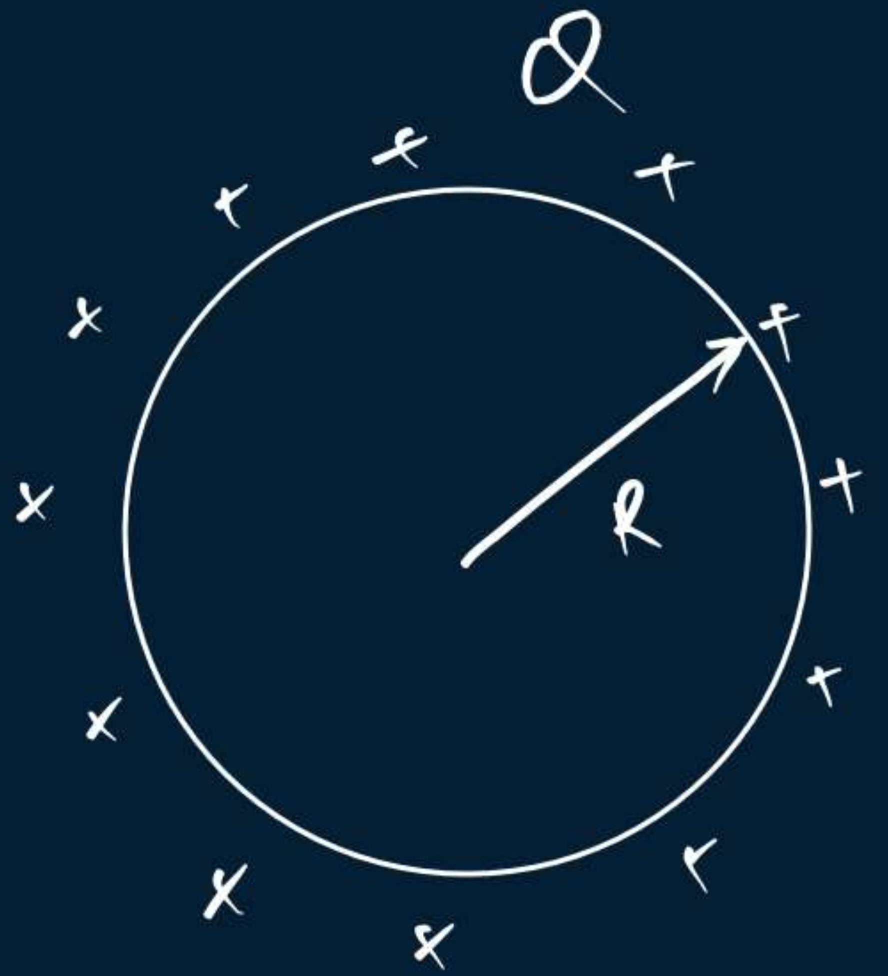
$$[Q] = [AT]$$

$$V = \frac{W}{Q}$$

$$= \frac{[ML^2T^{-2}]}{[AT]}$$

$$[V] = [ML^2T^{-3}A^{-1}]$$

Capacitance of a Spherical Conductor



$$Q = CV$$

$$\cancel{Q} = C\,\frac{K\cancel{Q}}{R}$$

$$\frac{R}{K} = C$$

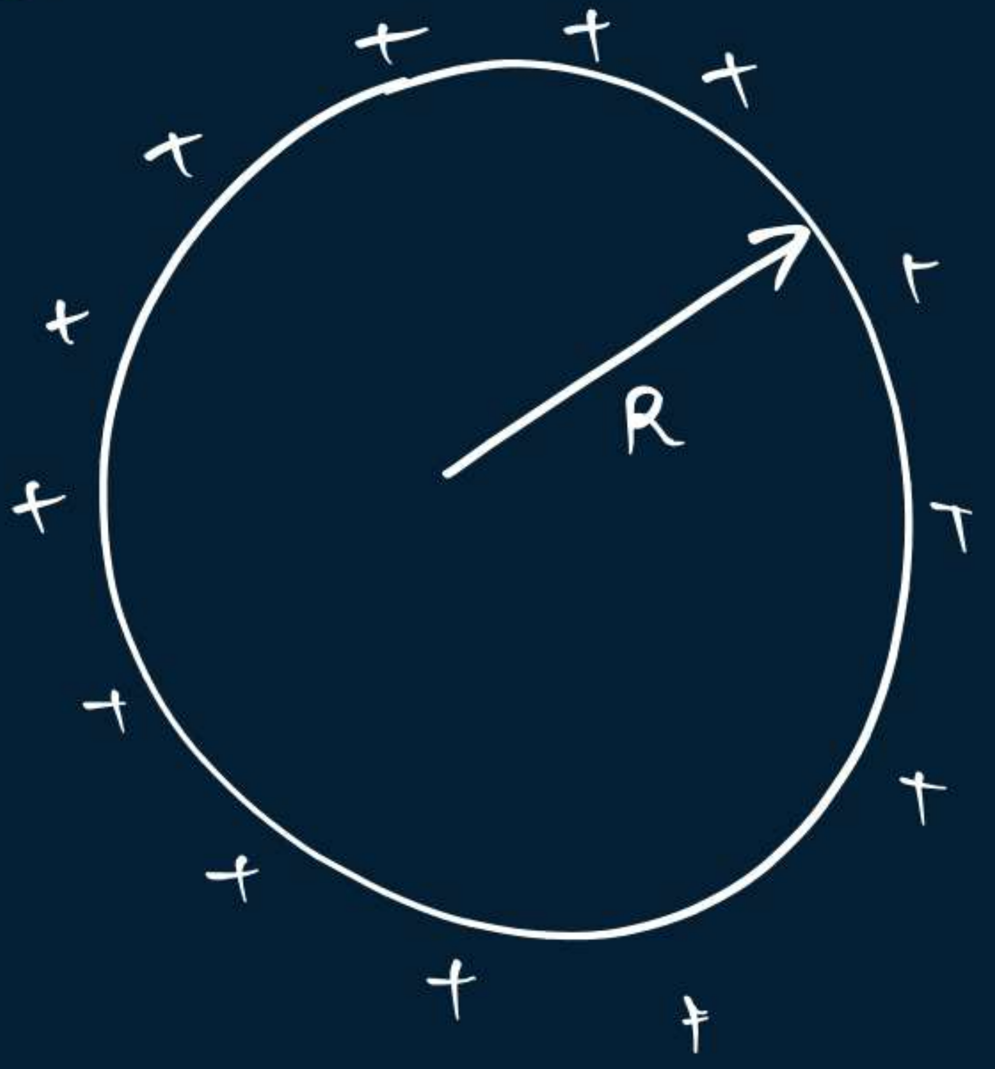
$$C = \frac{R}{\frac{1}{4\pi\epsilon_0}} = 4\pi\epsilon_0 R$$

$$* \boxed{C = 4\pi\epsilon_0 R}$$

$C \propto R$ ✓

Farad is a very large unit

1 Farad = 1F



$$C = 4\pi\epsilon_0 R$$

$$1 = 4\pi\epsilon_0 R$$

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

$$K = R$$

$$\boxed{9\times10^{9}\,m = R}$$

$$\boxed{\begin{aligned} R_e &= 6400\,km \\ &= 6400\times1000\ m \end{aligned}}$$

$$R = 9{,}00{,}00{,}00{,}000\ m$$

$= 900$ crore metre

Capacitance of a Parallel Plate Capacitor

$d \rightarrow$ separation b/w plates (m)

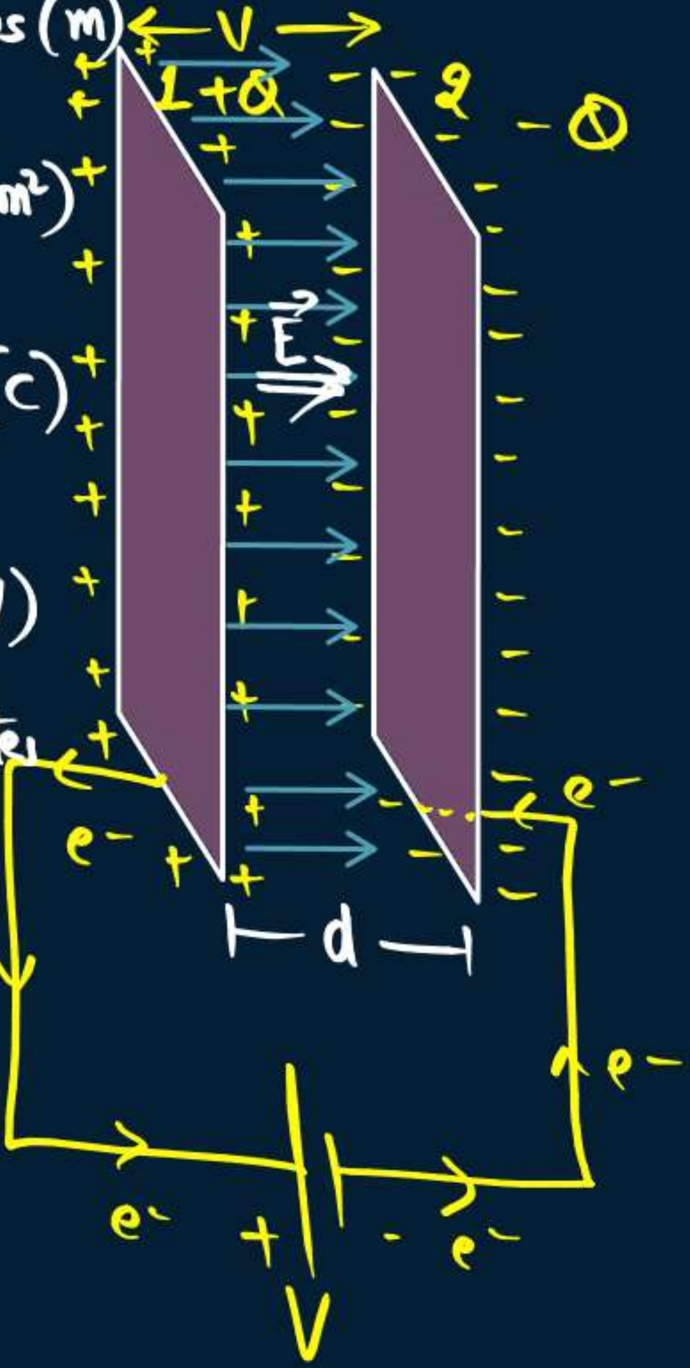
$A \rightarrow$ Area of the plate (m^2)

$Q \rightarrow$ charge on either plate (C)

$V \rightarrow$ Potential difference b/w plates (V)

$E \rightarrow$ Electric field b/w plates

$F \rightarrow$ Force b/w the plates



$$Q = CV$$

$$C = \frac{Q}{V}$$

$$V = E.d$$

$$C = \frac{Q}{Ed}$$

$$C = \frac{Q}{\frac{\sigma}{\epsilon_0} d}$$

We know that,

$$\sigma = \frac{Q}{A}$$

$$C = \frac{\cancel{Q}}{\frac{\cancel{Q} d}{A\epsilon_0}}$$

$$\boxed{C = \frac{\epsilon_0 A}{d}}$$

C depends on:-

i) Medium b/w plates

ii) Area

iii) Separation

Y.K.B.

$$E = -\frac{dV}{dr}$$

$$dV = -\int E \cdot dr$$

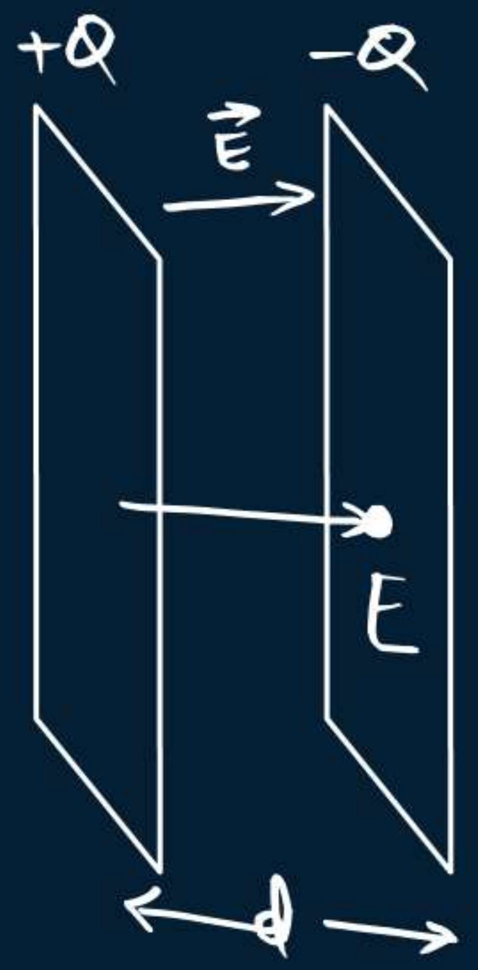
Y.K.B.

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

$$E = \frac{\sigma}{\epsilon_0}$$

Force between Parallel Plate Capacitor

Not in NCERT



Force exerted by one plate on another.

$$F = qE$$

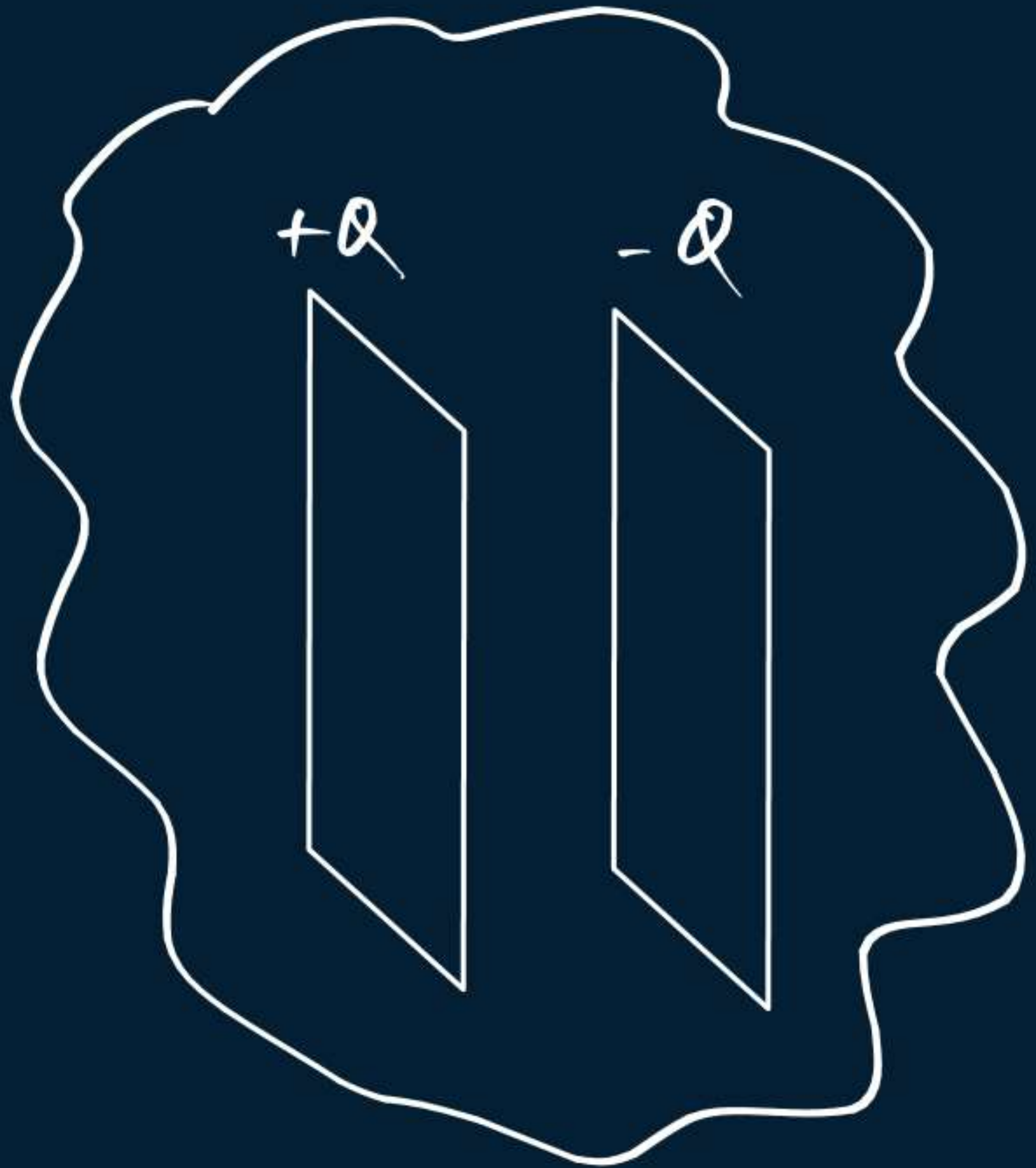
$$= Q\,E_{\text{single plate}}$$

$$= Q \cdot \frac{\sigma}{2\epsilon_0}$$

$$= Q \cdot \frac{Q}{A2\epsilon_0}$$

* $$\boxed{F = \frac{Q^2}{2A\epsilon_0}}$$

Net Charge on Parallel Plate Capacitor



$$Q_{net}^{capacitor} = Q_1 + Q_2$$
$$= +Q + (-Q)$$
$$= Q - Q$$
$$= 0$$

QUESTION

$$E = \frac{\sigma}{\epsilon_0}$$

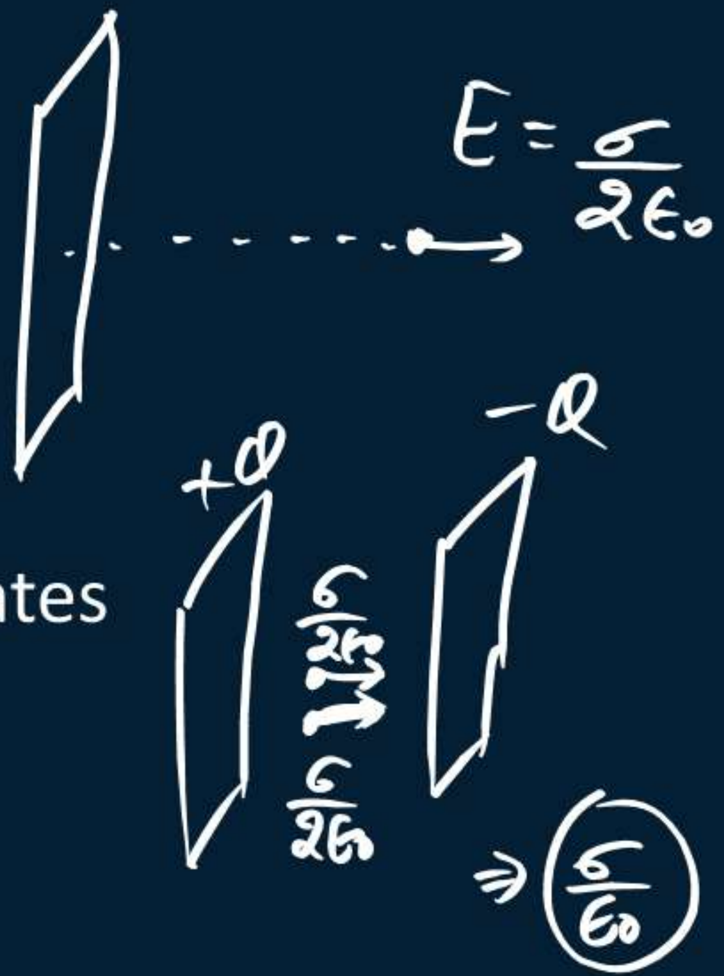
The intensity of electric field at a point between the plates of a charged capacitor

A Is directly proportional to the distance between the plates

B Is inversely proportional to the distance between the plates

C Is inversely proportional to the square of the distance between the plates

D Does not depend upon the distance between the plates



QUESTION

Capacitance Capacitor

The capacity of parallel plate condenser depends on

A. The type of metal used

B. The thickness of plates

C. The potential applied across the plates

D. The separation between the plates

$$\boxed{C = \frac{\epsilon_0 A}{d}}$$

$$C \uparrow \propto \frac{1}{d \downarrow}$$

QUESTION

$C = \frac{\epsilon_0 A}{d}$ or $C\uparrow \propto \frac{1}{d\downarrow}$

The capacity of a parallel plate condenser is C. When the distance between the plates is halved, its capacity is

d $\qquad$ $\frac{d}{2}$

C $\qquad$ C'

$C = \frac{\epsilon_0 A}{d}$ ...... (1)

$C' = \frac{\epsilon_0 A}{\frac{d}{2}}$ ...... (2)

$\frac{C'}{C} = \frac{\frac{\cancel{\epsilon_0 A}}{\cancel{d}/2}}{\frac{\cancel{\epsilon_0 A}}{\cancel{d}}} = \frac{\frac{1}{\frac{1}{2}}}{1}$

$\frac{C'}{C} = \frac{2}{1}$

$\boxed{C' = 2C}$ ✓

QUESTION

The capacity of a parallel plate condenser is 15μF, when the distance between its plates is 6 cm. if the distance between the plates is reduced to 2 cm, then the capacity of this parallel plate condenser will be?

A 15 μF

B 30 μF

C 45 μF

D 60 μF

$6\text{cm} \longrightarrow 2\text{ cm}$

$d \qquad \frac{d}{3}$

$C \qquad 3C$

QUESTION

H.W.

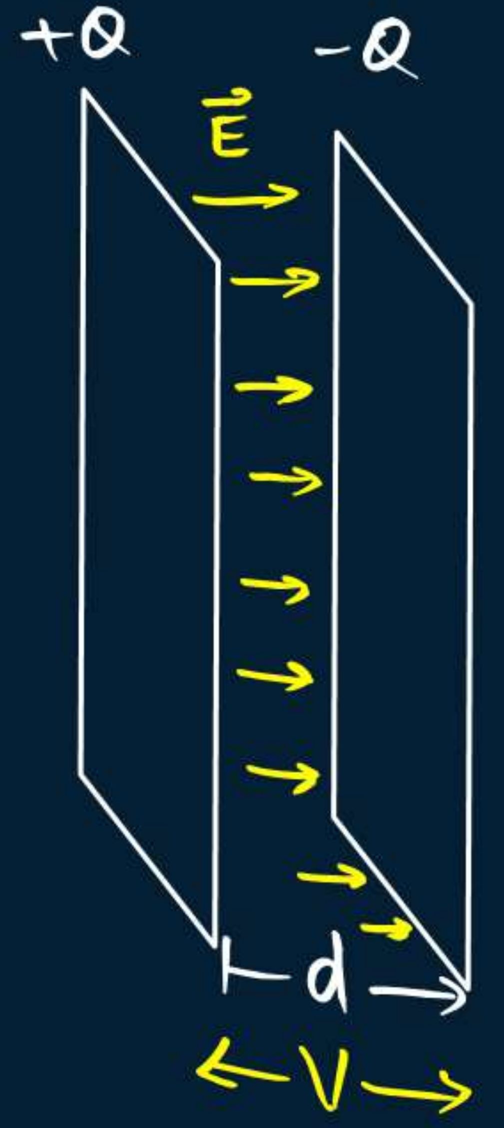
The capacitor of plate area $4\ cm^2$ and distance between plates = 0.04 mm is connected to a 3 V battery. Find

a) capacitance b) charge stored on the capacitor.

$$C = \frac{\epsilon_0 A}{d}$$

$$Q = CV$$

Energy Stored in a Capacitor



$$W = qV$$

$$\int dW = \int q\, dV$$

$$W = \int q \cdot dV$$

We put $q = CV$

$$W = \int CV \cdot dV$$

$$= C\int V \cdot dV$$

$$U = \frac{CV^2}{2} = \frac{1}{2}CV^2$$

$$C = \frac{Q}{V}$$

$$\boxed{U = \frac{1}{2}CV^2}$$

$$U = \frac{1}{2}\frac{Q}{\cancel{V}}V^{\cancel{2}}$$

$$\boxed{U = \frac{1}{2}QV}$$

$$U = \frac{1}{2}Q \cdot \frac{Q}{C}$$

$$\boxed{U = \frac{Q^2}{2C}}$$

Y.K.B.

$$\int x \cdot dx = \frac{x^{1+1}}{1+1}$$

$$= \frac{x^2}{2}$$

QUESTION

The energy stored in a condenser of capacity C which has been raised to a potential *V* is given by

A) 1/2 CV

B) 1/2 CV^2

C) CV

D) 1/2VC

$$U = \frac{1}{2} CV^2$$

$$U = \frac{1}{2} QV$$

$$U = \frac{Q^2}{2C}$$

QUESTION

A 12 pF capacitor is connected to a 50V battery. How much electrostatic energy is stored in the capacitor?

(A) 1.5×10^{-8} J

(B) 2.5×10^{-7} J

(C) 3.5×10^{-5} J

(D) 4.5×10^{-2} J

$$\boxed{U = \frac{1}{2}CV^2} = \frac{Q^2}{2C} = \frac{1}{2}QV$$

$$U = \frac{1}{2}CV^2$$

$$= \frac{1}{\cancel{2}} \times \overset{6}{\cancel{12}} \times 10^{-12} \times 50 \times 50$$

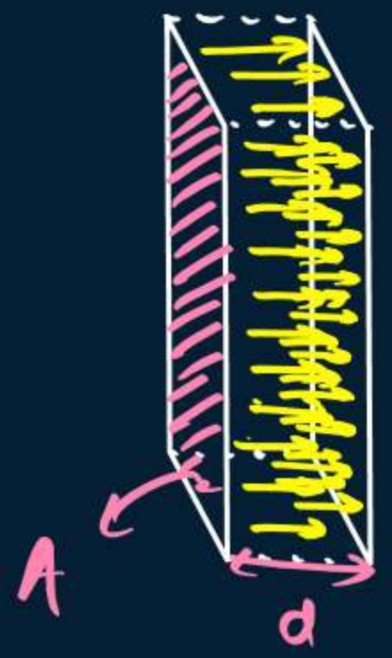
$$= 15000 \times 10^{-12}$$

$$= 1.5 \times 10^{4} \times 10^{-12}$$

$$\boxed{U = 1.5 \times 10^{-8}\,J}$$

Energy Density in a Capacitor

Energy density = $\dfrac{\text{Energy stored}}{\text{Volume}}$



$$u = \frac{U}{\text{Vol.}}$$

$$u = \frac{\frac{1}{2}CV^2}{Ad}$$

We know that, $C = \dfrac{\epsilon_0 A}{d}$

$$u = \frac{1}{2}\frac{\epsilon_0 A}{dAd}V^2$$

here, $V = E.d$

$$u = \frac{1}{2}\frac{\epsilon_0 \cancel{A}}{\cancel{d}\cancel{A}\cancel{d}}E^2\cancel{d^2}$$

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

QUESTION

PYQ

A parallel plate capacitor has a uniform electric field E in the space between the plates. If the distance between the plates is d and area of each plate is A, the energy stored in the capacitor is

A. $\varepsilon_0 E A d$

B. $\frac{1}{2}\varepsilon_0 E^2 A d$

C. $\frac{1}{2}\varepsilon_0 E^2$

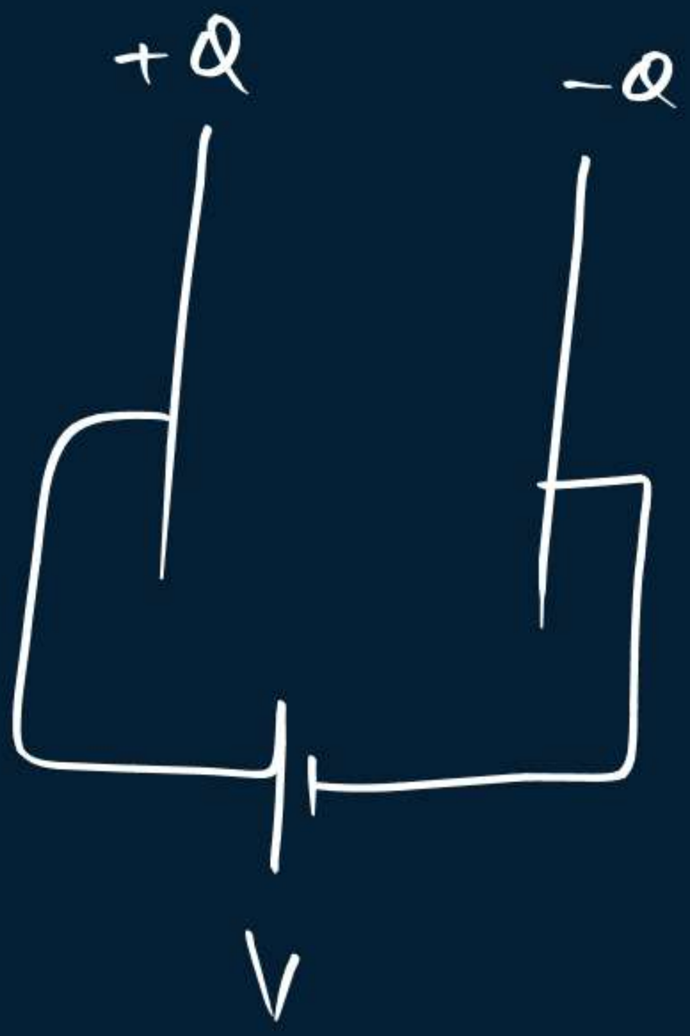
D. $\frac{E^2 A d}{\varepsilon_0}$

$$u = \frac{U}{\text{Vol.}}$$

$$U = u \cdot \text{Vol}$$

$$U = \frac{1}{2}\varepsilon_0 E^2 \times Ad$$

Work Done and Heat Produced in a Circuit



Workdone by Battery :- $W = qV$

$W = CVV$

$$\boxed{W = CV^2}$$

Energy Stored on capacitor :- $\boxed{U = \frac{1}{2}CV^2}$

Workdone by Batteriya = Electric Energy Stored in a capacitor + Heat dissipation

$$CV^2 = \frac{1}{2}CV^2 + \text{Heat dissipated}$$

$$CV^2 - \frac{1}{2}CV^2 = \text{Heat}$$

$$\frac{1}{2}CV^2 = \text{Heat}$$

QUESTION

A battery does 200 J of work in charging a capacitor. The energy stored in the capacitor is

(A) 200 J

(B) 100 J

(C) 50 J

(D) 400 J

QUESTION

An uncharged capacitor is fully charged with a battery. The ratio of energy stored in the capacitor to the work done by the battery in this process is

(A) 1 : 2

(B) 2 : 1

(C) 1 : 1

(D) 2 : 3

$$\frac{U}{W} = \frac{1}{2}$$

1:2

Homework

Notes

DPP

Revision

PARISHRAM

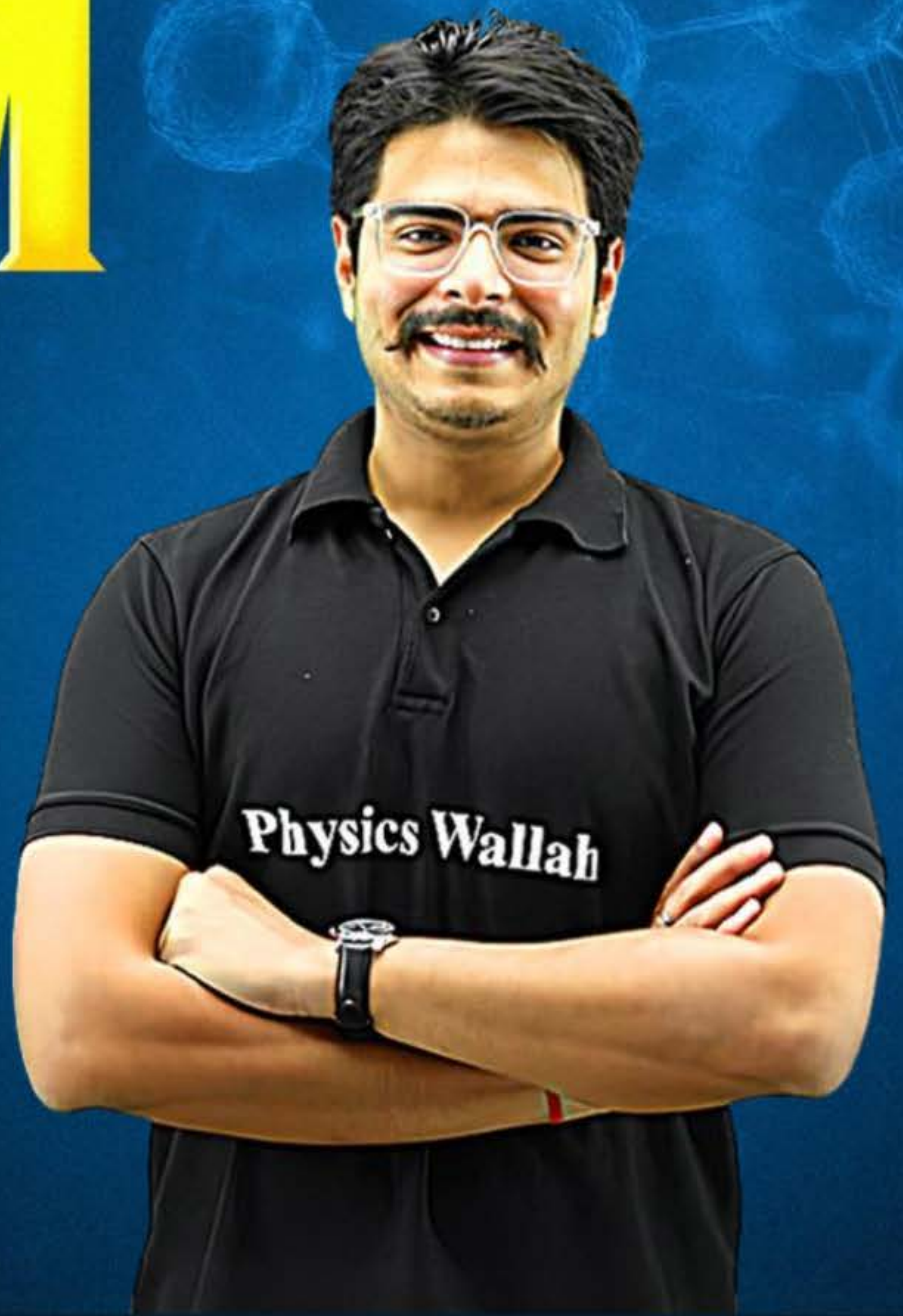
2026

Lecture - 08

Electrostatic Potential and Capacitance

PHYSICS | Lecture - 08

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Capacitors in Combination – Series and Parallel
- **B**
- **C**
- **D**
- **E**

HW QUESTION

The capacitor of plate area $4\ cm^2$ and distance between plates $= 0.04$ mm is connected to a 3 V battery. Find

a) capacitance b) charge stored on the capacitor.

a) $C = \frac{\epsilon_0 A}{d}$

$= \frac{8.85 \times 10^{-12} \times \cancel{4}^{1} \times 10^{\cancel{-4}^{-1}}}{\cancel{0.04} \times \cancel{10^{-3}}} \times 10^{2}$

$= 8.85 \times 10^{-12} \times 10^{1}$

$= 88.5 \times 10^{-12} = 88.5\ pF$

b) $Q = CV$

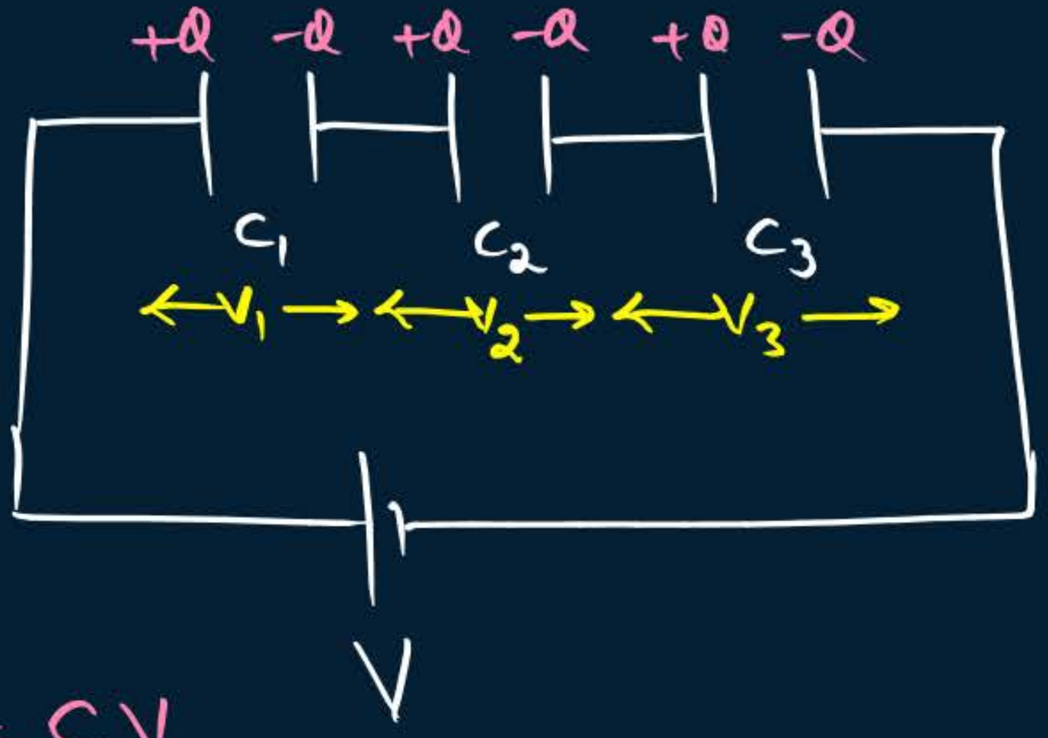
$= 88.5 \times 3$

$= \boxed{}\ pC$

Capacitors in Combination – a) Series

i) Charge same

ii) Potential divider



$$Q = CV$$

Const. $\frac{Q}{C} = V$

RD× Ratta

$$\boxed{V \propto \frac{1}{C}}$$

if $C \uparrow$ then $V \downarrow$

$C \downarrow$ then $V \uparrow$

$$V = V_1 + V_2 + V_3$$

$$\frac{Q}{C_{net}} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\frac{\cancel{Q}}{C_{net}} = \cancel{Q}\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

Capacitors in Series

$$\boxed{\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Spl. Case

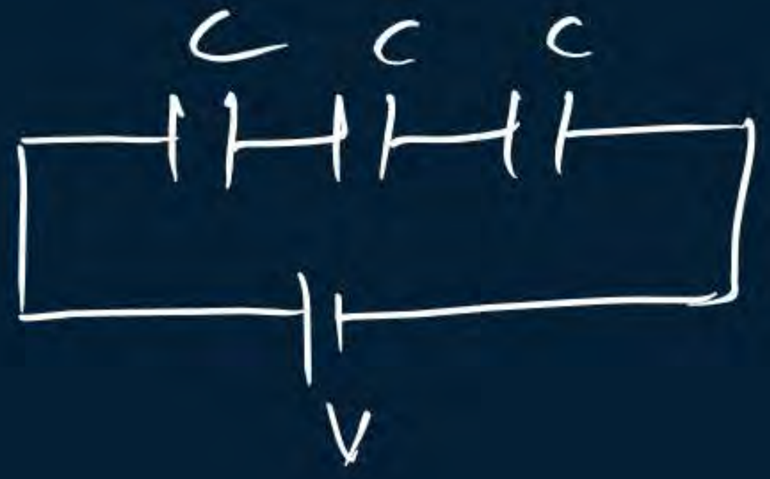
'n' capacitors are identical.

$$C_1 = C_2 = C_3 = C$$

$$\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} \dots n$$

$$\frac{1}{C_s} = \frac{n}{C} \Rightarrow \boxed{C_s = \frac{C}{n}}$$

Q

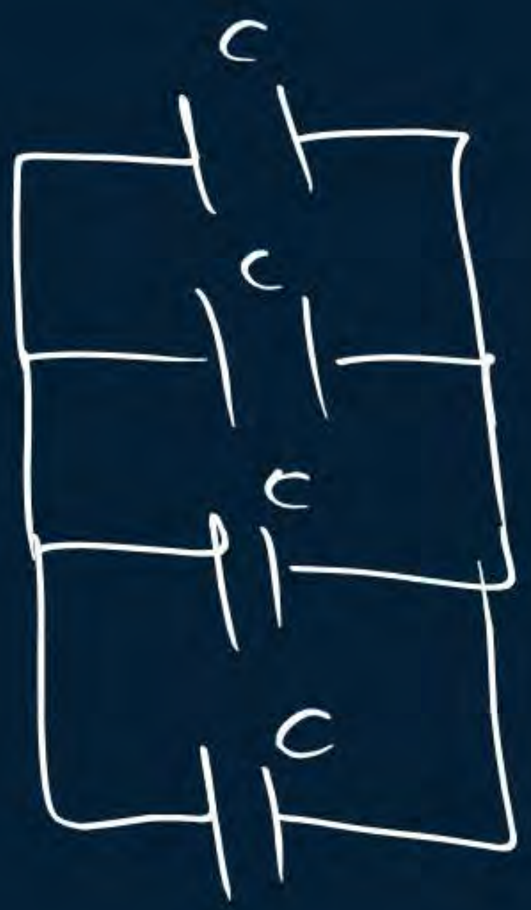


find $C_{net} = ?$

$$C_s = \frac{C}{n}$$

$$\boxed{C_s = \frac{C}{3}}$$ Ans

Q



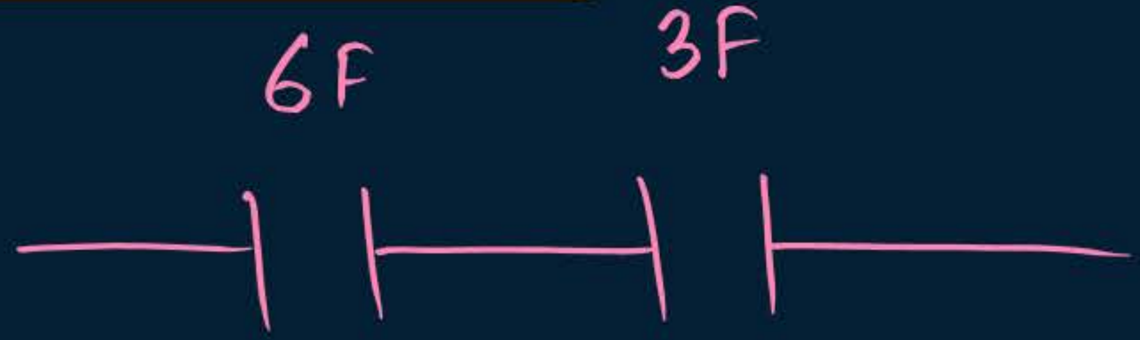
$$C_{net} = nC$$

$$C_{net} = 4C$$

Famous Values

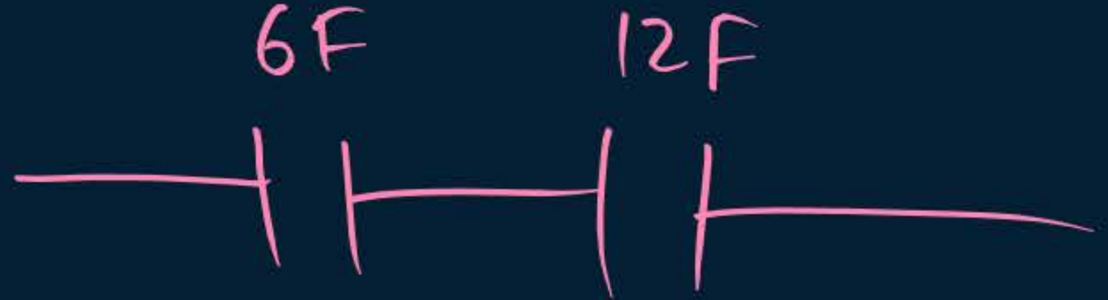
$$RD_x :- \frac{C_1 C_2}{C_1 + C_2}$$

Ex-1)



$$\equiv \frac{6\times 3}{6+3} = \frac{\cancel{18}}{\cancel{9}} = 2F$$

Ex-2)



$$\equiv \frac{6\times 12}{6+12} = \frac{\cancel{72}^{\,4}}{\cancel{18}_{\,1}} = 4F$$

Ex-3)

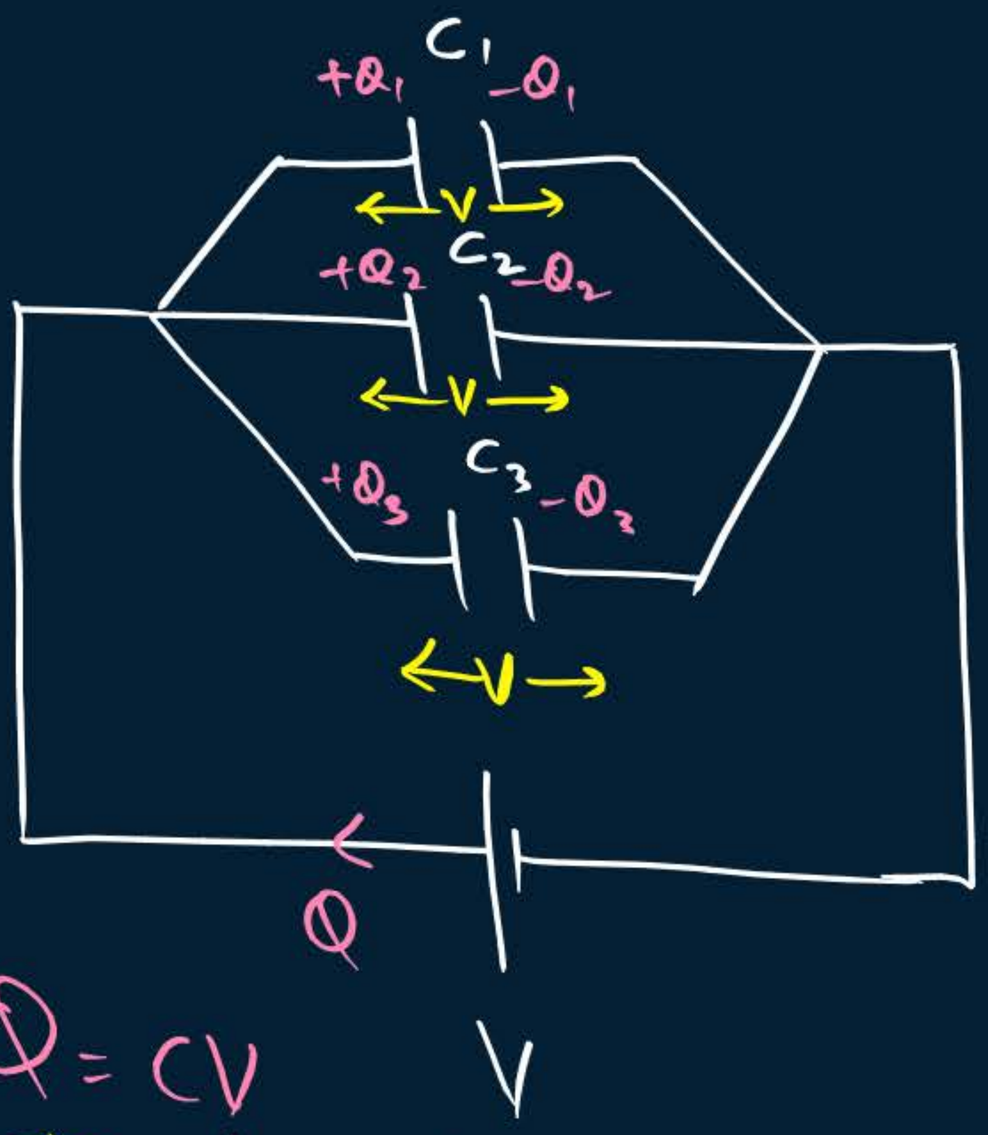
$$\equiv \frac{12\times 4}{12+4} = \frac{\cancel{48}}{\cancel{16}} = 3F$$

Capacitors in Combination – b) Parallel

i) Potential same

ii) Charge divide

here the charge divides,



$$Q_{net} = Q_1 + Q_2 + Q_3$$

$$C_{net} V = C_1 V + C_2 V + C_3 V$$

$$C_{net} \cancel{V} = \cancel{V}(C_1 + C_2 + C_3)$$

$$\boxed{C_p = C_1 + C_2 + C_3}$$

$Q = CV$ → const.

$Q \propto C$ ⟹ if $C\uparrow$ $Q\uparrow$, $C\downarrow$ $Q\downarrow$

Spl. case :-

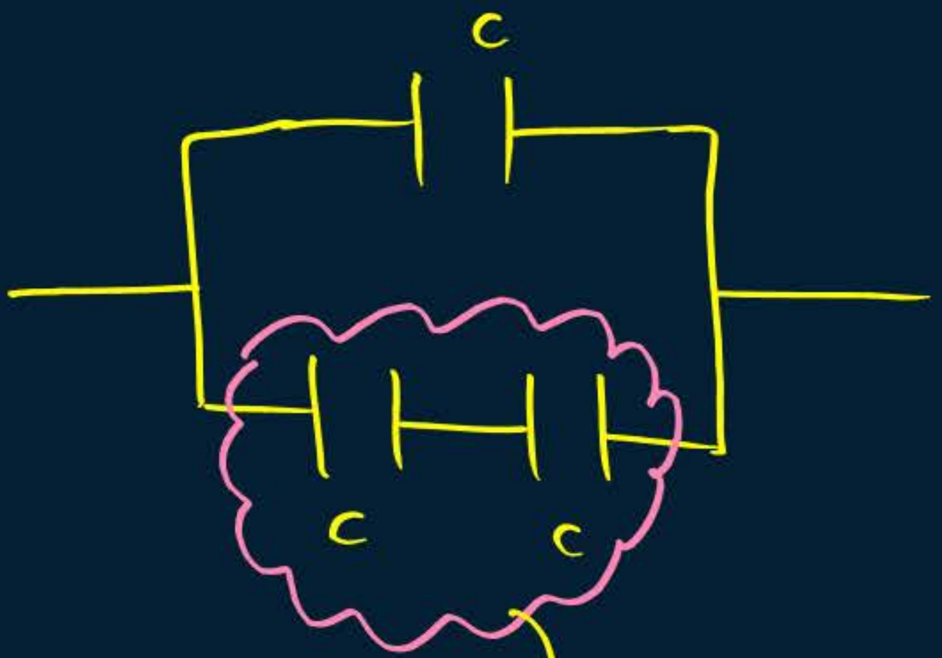
if 'n' (identical) capacitors are connected in Parallel.

$$C_p = C_1 + C_2 + C_3$$

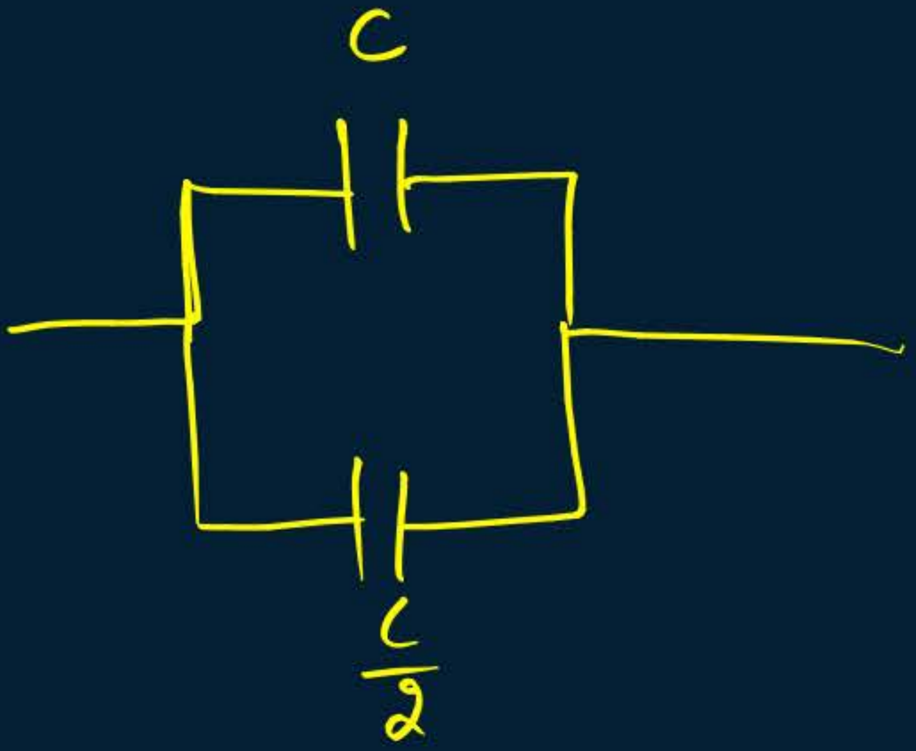
$$C_p = \underbrace{C + C + C + C + \dots}_{n}$$

$$* \boxed{C_p = nC}$$

RDx Patterns



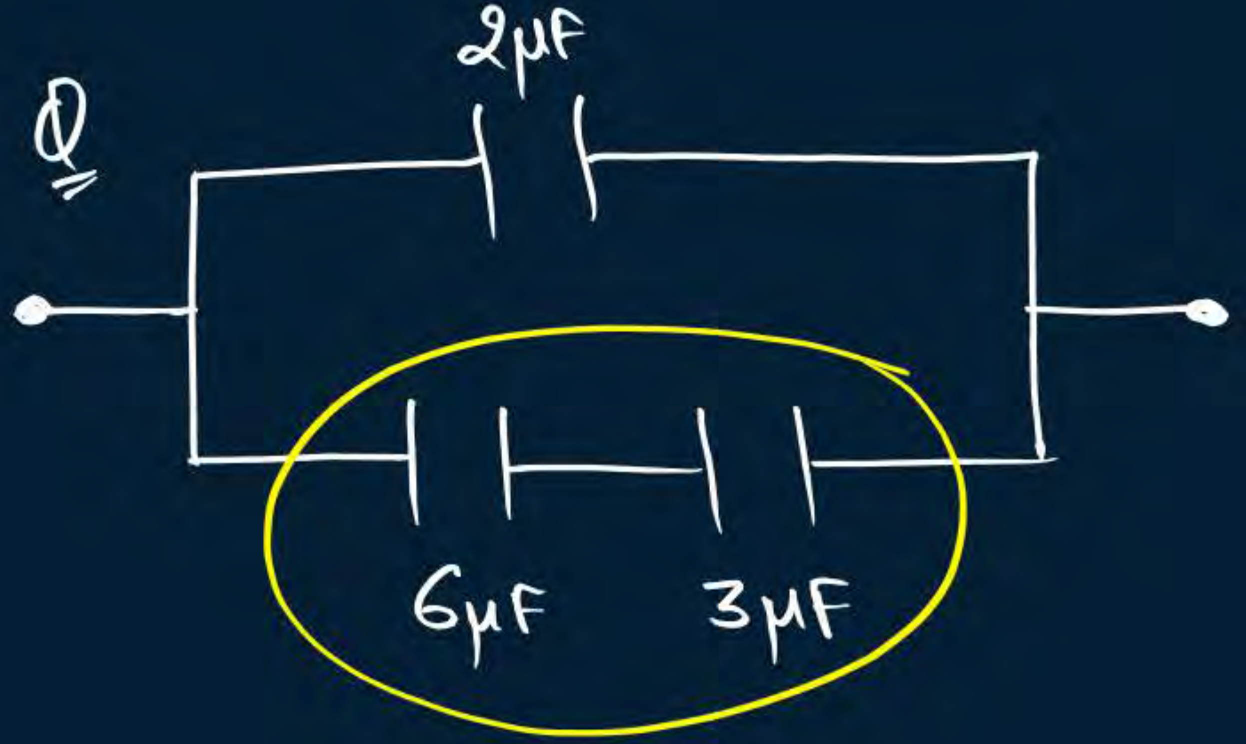
$\equiv$



$\equiv \frac{C}{1} + \frac{C}{2} = \frac{2C + C}{2} = \frac{3C}{2}$

Ans

$\frac{C}{n} = \frac{C}{2}$ ✓



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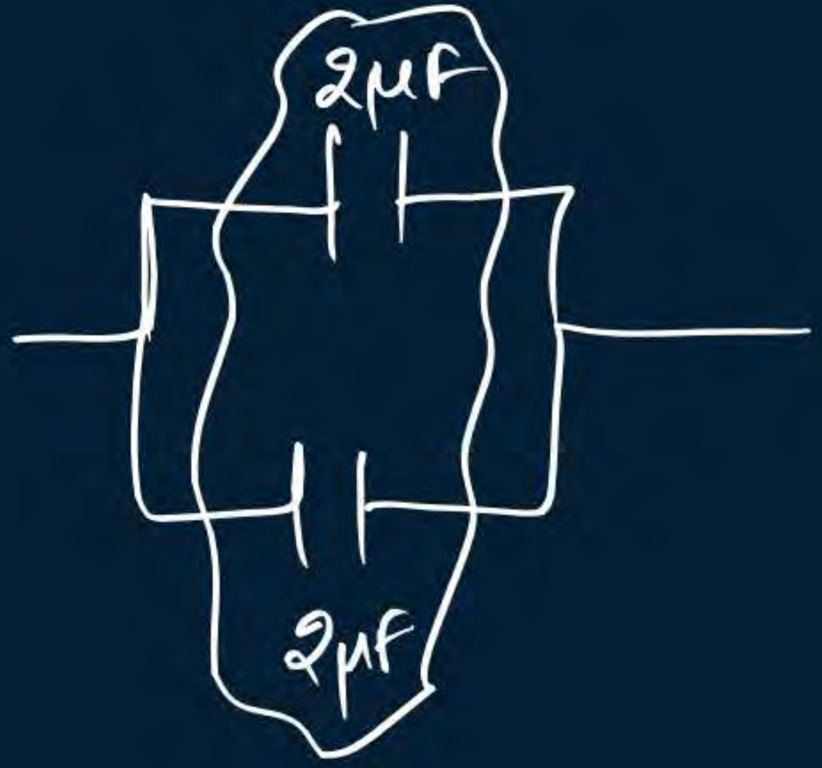
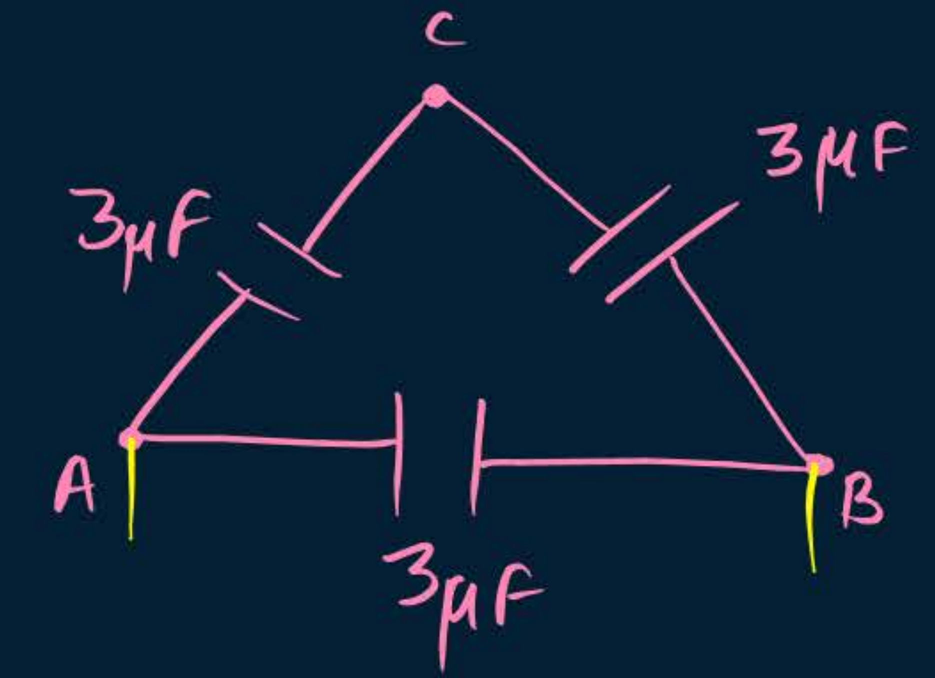


≡

Ans



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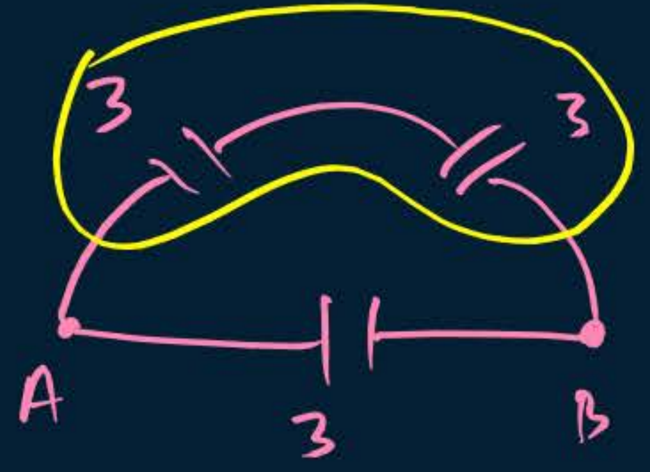

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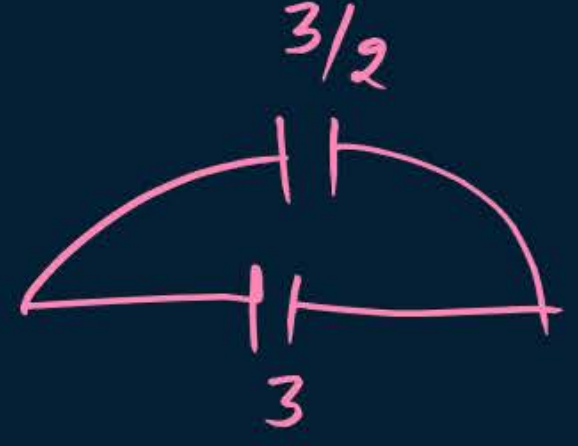
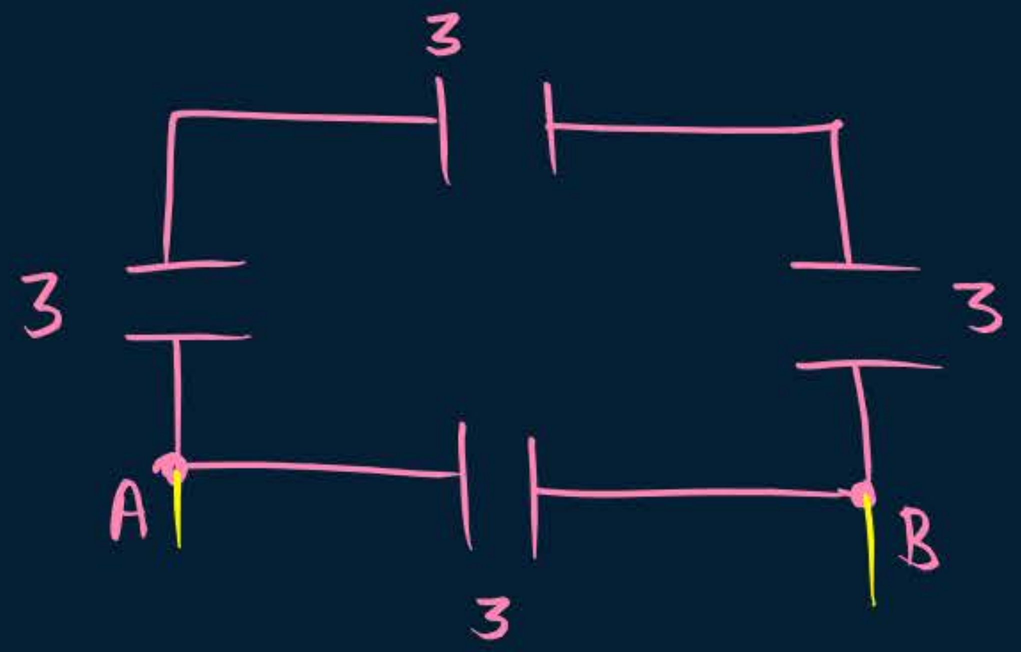


$\Rightarrow 3+\frac{3}{2}=\frac{9}{2}$

$= 4.5\mu F$

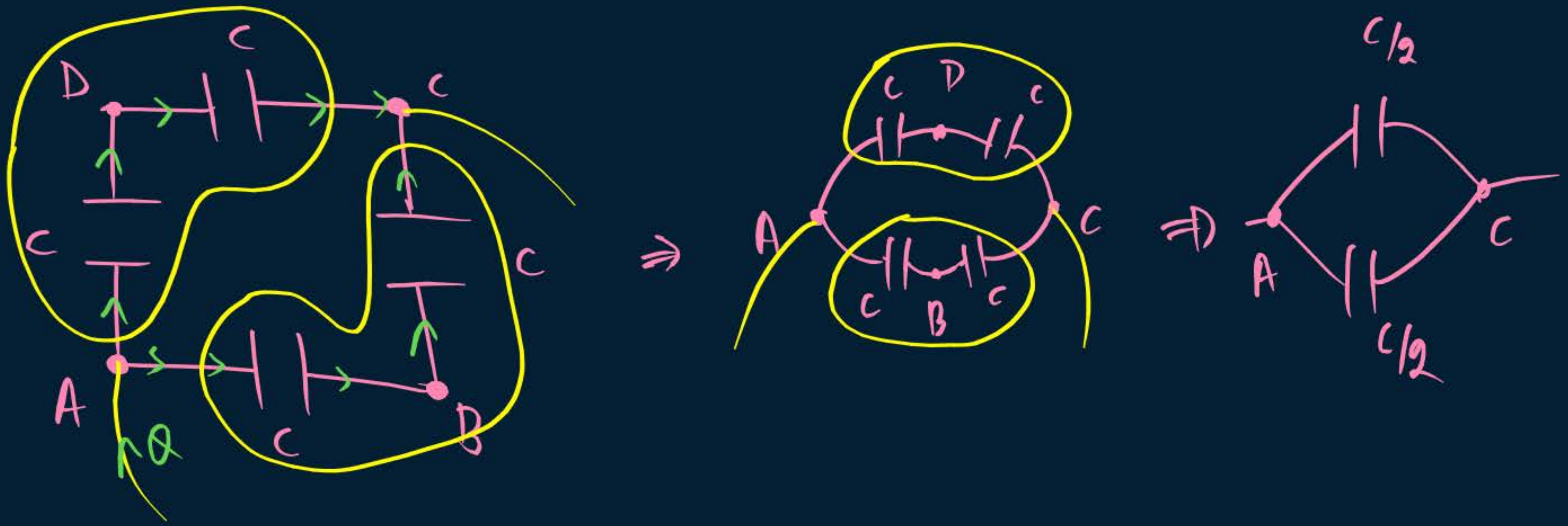


⇒

⇒

$\Rightarrow 3+1=4\mu F$

$3 + \frac{3}{4} = \frac{15}{4}\,\mu F$



$= \frac{C}{2} + \frac{C}{2} = C$

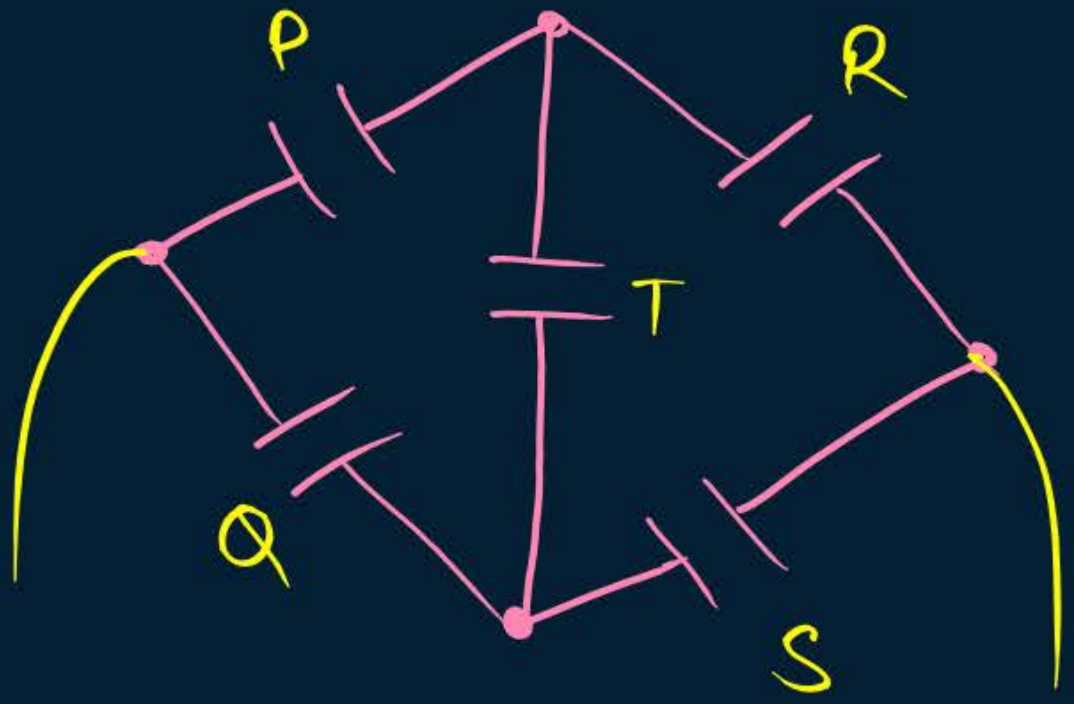
Ans

Imp.

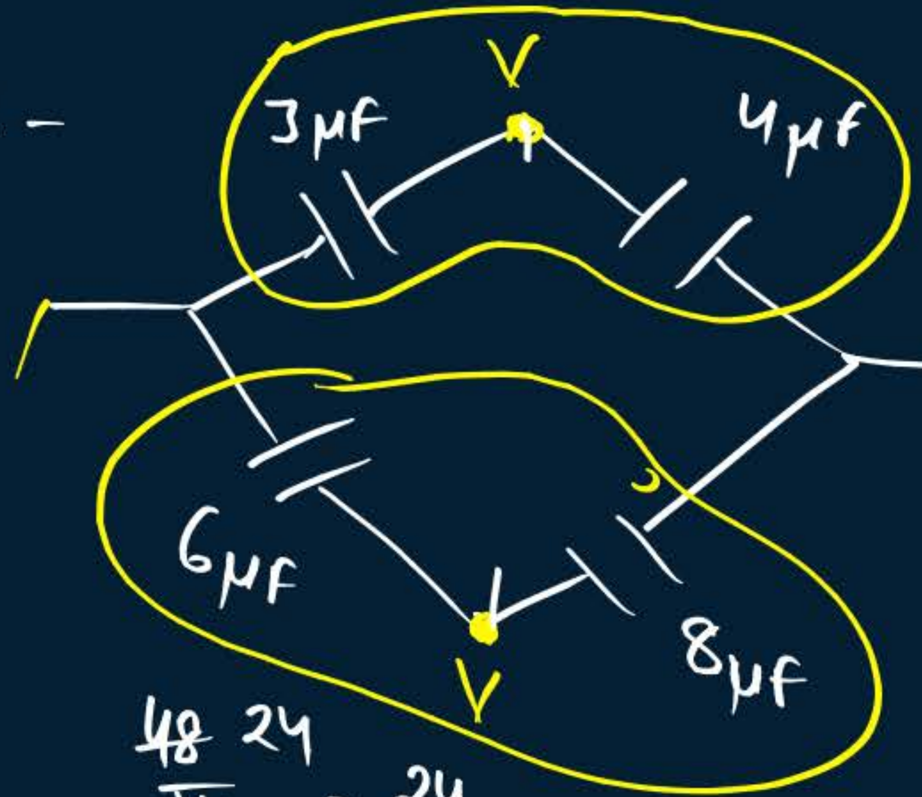
Wheatstone Bridge

→ Balanced $\left(\frac{P}{Q}=\frac{R}{S}\right)$ ignore T and solve.

→ Unbalanced



Ex -



$$\frac{\cancel{3}^{1}}{\cancel{6}_{2}}=\frac{\cancel{4}^{1}}{\cancel{8}_{2}}$$

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

Bal. W.S.B.

$\frac{12}{7}$

$$\frac{\cancel{48}^{24}}{\cancel{14}_{7}}=\frac{24}{7}$$

$$\Rightarrow \frac{12}{7}+\frac{24}{7}=\frac{36}{7}\ \text{Ans}$$ ✓

QUESTION

Three capacitors of capacitances 3μF, 9μF and 18μF are connected once in series and another time in parallel. The ratio equivalent capacitance in the two cases (C_S/C_P) will be

(A) 1 : 15

(B) 15 : 1

(C) 1 : 1

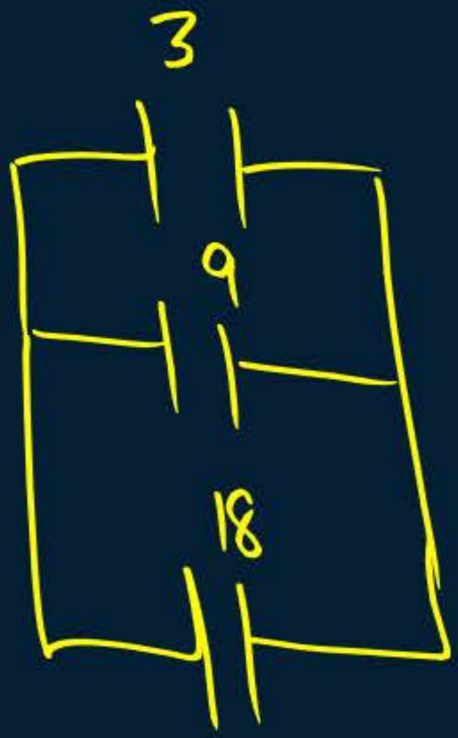
(D) 1 : 3

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_s} = \frac{1}{3} + \frac{1}{9} + \frac{1}{18}$$

$$\frac{1}{C_s} = \frac{6+2+1}{18} = \frac{\cancel{9}\,1}{\cancel{18}\,2}$$

$$C_s = 2\,\mu F$$

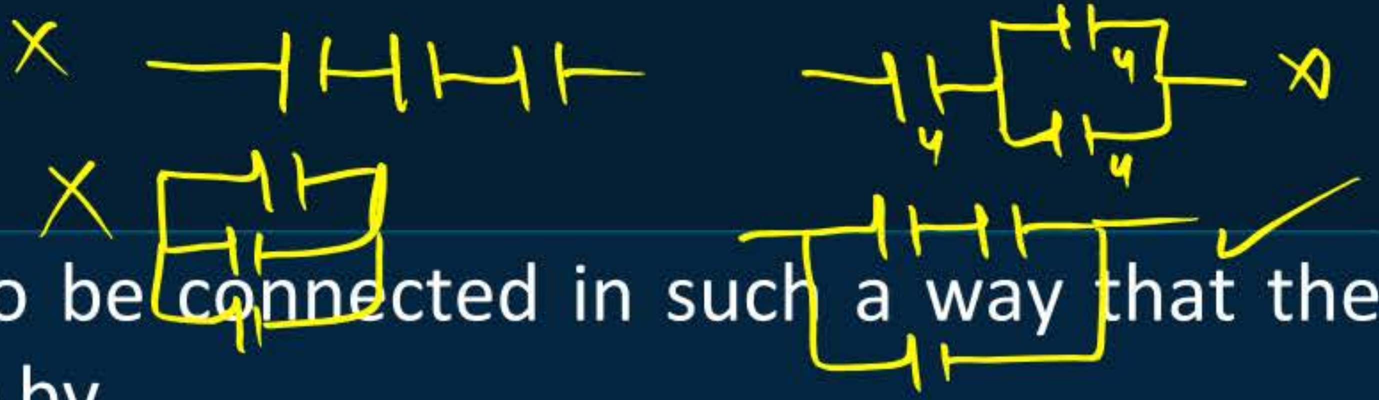


$$C_P = 3+9+18$$
$$= 30\,\mu F$$

$$\frac{C_s}{C_P} = \frac{\cancel{2}\,\cancel{\mu F}}{\cancel{30}\,\cancel{\mu F}} = \frac{1}{15}$$

$$= 1:15$$

QUESTION



Three capacitors each of capacity 4 μF are to be connected in such a way that the effective capacitance is 6 μF. This can be done by

(A) connecting all of them in series

$C_s = \frac{C}{n} = \frac{C}{3} = \frac{4}{3}$

(B) connecting them in parallel

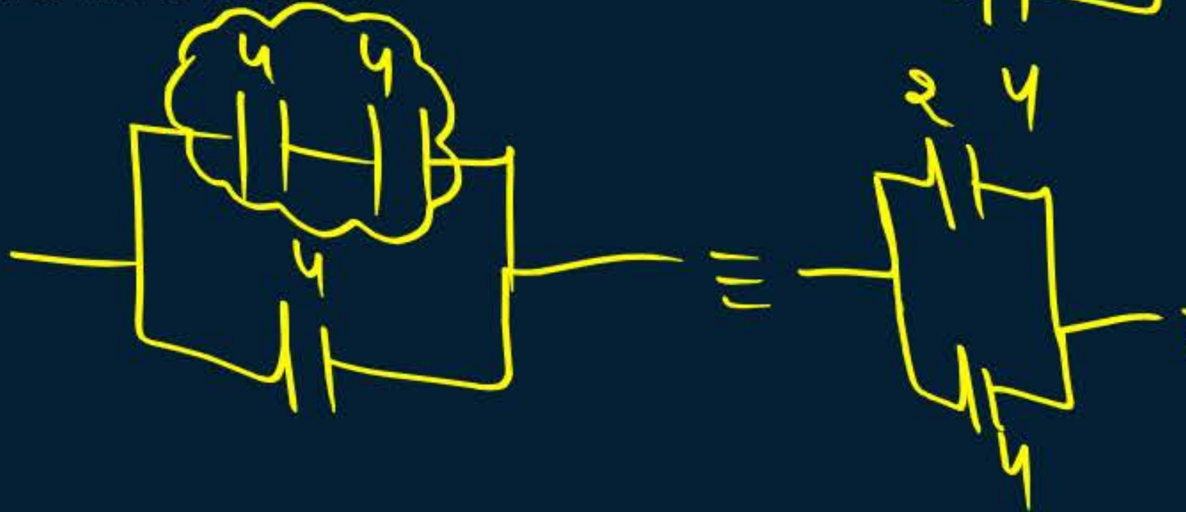
$\equiv C_p = nC \Rightarrow 3 \times 4 = 12\,\mu F$

(C) connecting two in series and one in parallel

(D) connecting two in parallel and one in series.

$\frac{1}{C_s} = \frac{1}{4} + \frac{1}{8} = \frac{2+1}{8} = \frac{3}{8}$

$C_s = \frac{8}{3}\,\mu F$

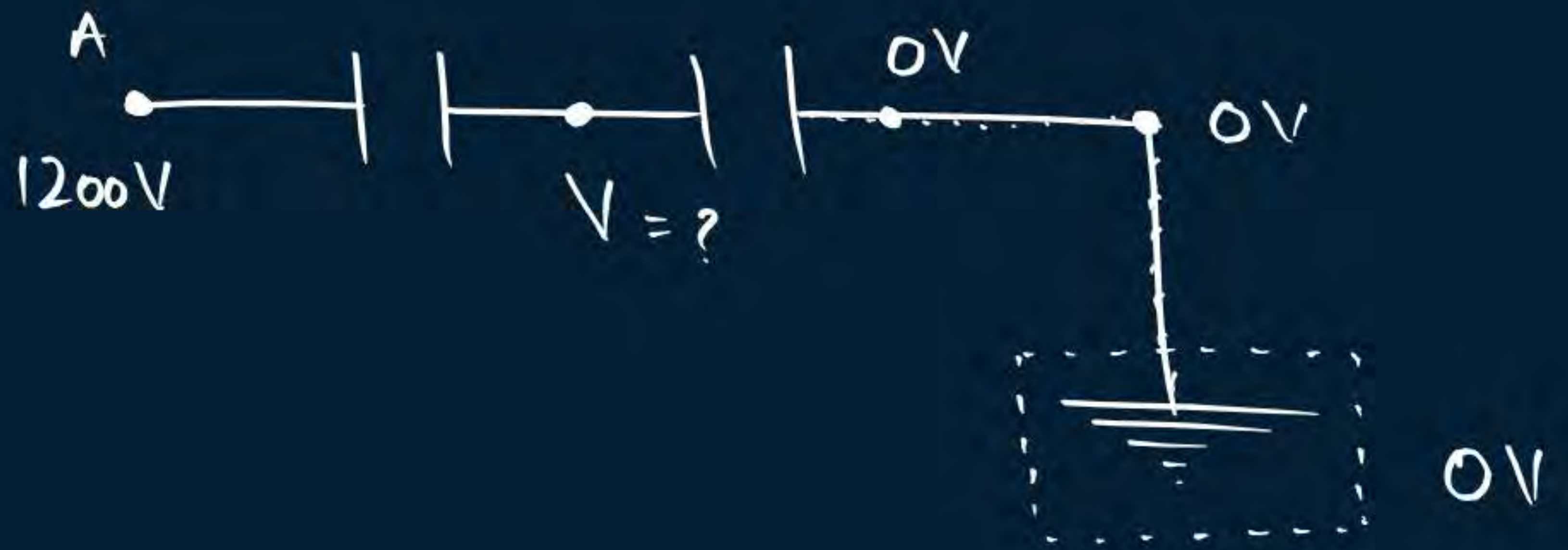


$\equiv 6\,\mu F$

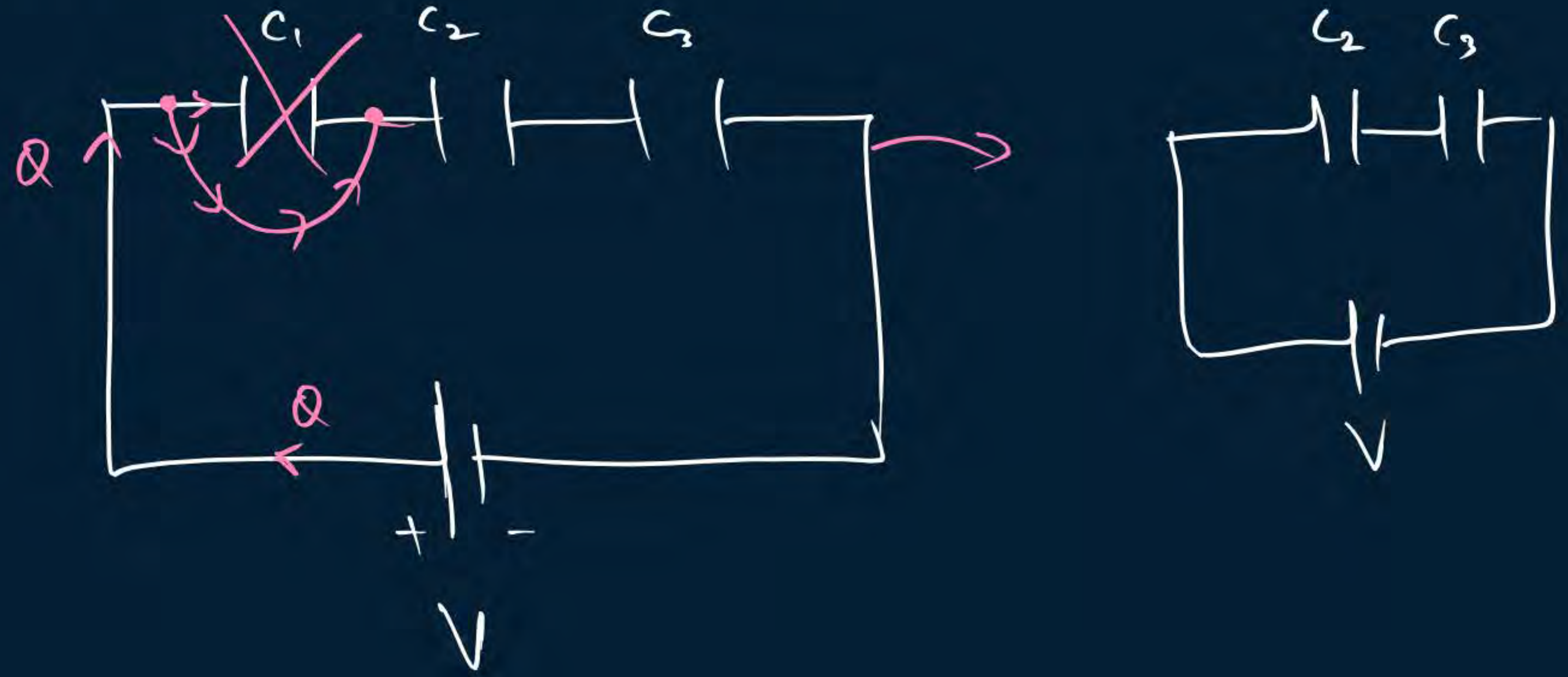
Earthing in a Circuit

or
Grounding

→ Directly connecting one side of the wire with zero potential.
(Earth connect)



Shorting a Circuit



QUESTION

$Q = CV$ $\quad Q_4 = 4CV$

$Q_2 = \frac{6C}{11}V$

A network of four capacitors of capacity equal to $C_1 = C$, $C_2 = 2C$, $C_3 = 3C$ and $C_4 = 4C$ are connected to a battery as shown in the figure. The ratio of the charges of C_2 and C_4 is

$Q_2 \quad Q_4$

(A) 4/7

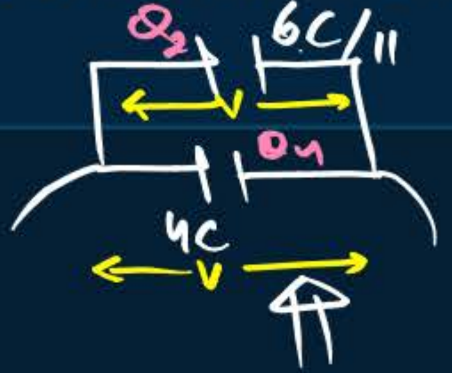
(B) 3/22

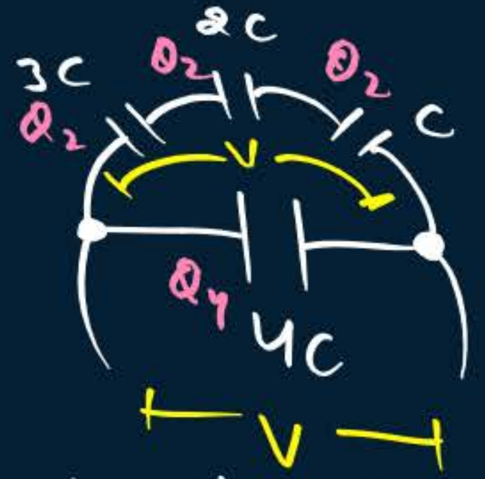
(C) 7/4

(D) 22/3

$$\frac{Q_2}{Q_4} = \frac{\frac{6CV}{11}}{4CV} = \frac{6\cancel{CV}}{44\cancel{CV}} = \frac{\cancel{6}\,3}{\cancel{44}\,22} = 3:22$$

$$\boxed{C_s = \frac{6C}{11}}$$

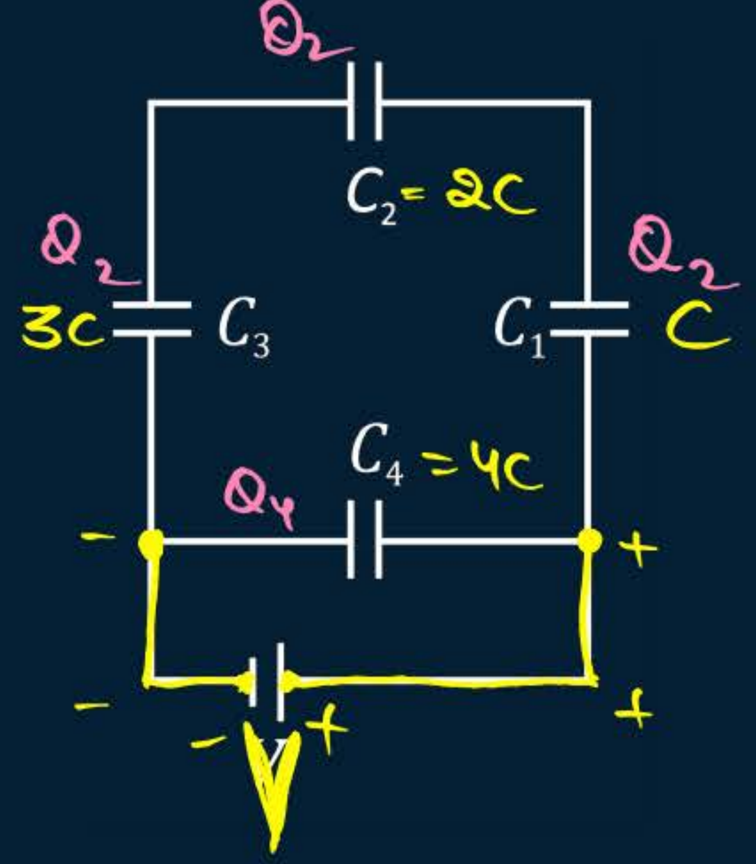




$$\frac{1}{C_s} = \frac{1}{3C} + \frac{1}{2C} + \frac{1}{C}$$

$$= \frac{1}{C}\left(\frac{1}{3} + \frac{1}{2} + \frac{1}{1}\right)$$

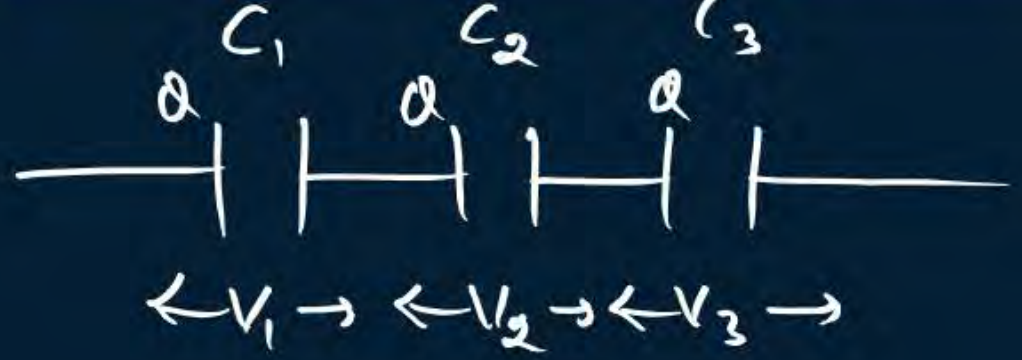
$$\frac{1}{C_s} = \frac{1}{C}\left(\frac{2+3+6}{6}\right) = \frac{11}{C6}$$



Energy Stored in Combination

$$U = \frac{Q^2}{2C}$$

Series :-



$$U_1 = \frac{Q^2}{2C_1}, \quad U_2 = \frac{Q^2}{2C_2}, \quad U_3 = \frac{Q^2}{2C_3}$$

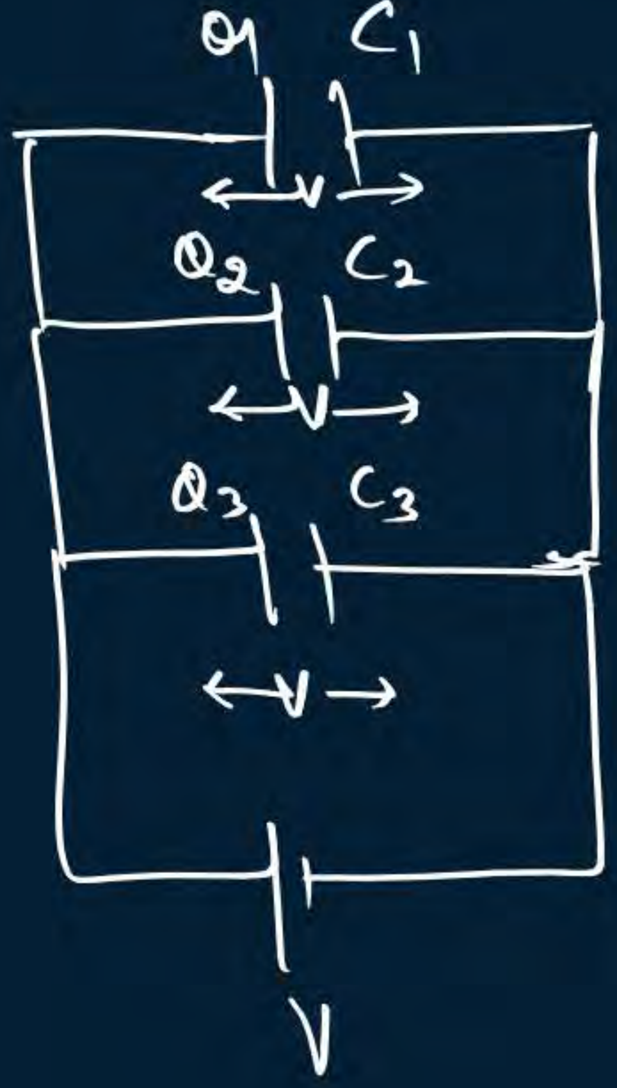
$$U_{net} = U_1 + U_2 + U_3$$

$$= \frac{Q^2}{2C_1} + \frac{Q^2}{2C_2} + \frac{Q^2}{2C_3}$$

$$= \frac{Q^2}{2}\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right] = \frac{Q^2}{2}\left[\frac{1}{C_s}\right]$$

* $\boxed{U_s = \frac{Q^2}{2C_s}}$

* Parallel :- $U = \frac{1}{2}CV^2$



$$U_1 = \frac{1}{2}C_1V^2, \quad U_2 = \frac{1}{2}C_2V^2, \quad U_3 = \frac{1}{2}C_3V^2$$

$$U_{net} = U_1 + U_2 + U_3 \ldots$$

$$= \frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2 + \frac{1}{2}C_3V^2 \ldots$$

$$= \frac{1}{2}V^2\left[C_1 + C_2 + C_3\right] = \frac{1}{2}V^2 C_P$$

$$\boxed{U_P = \frac{1}{2}C_PV^2}$$

QUESTION

$C_s = \frac{C}{n} = \frac{C_1}{n_1}$ $\quad C_p = nC = n_2 C_2$

A series combination of n_1 capacitors, each of value C_1, is charged by a source of potential difference $4V$. When another parallel combination of n_2 capacitors, each of the value C_2, is charged by a source of potential difference V, it has the same (total) energy stored in it, as the first combination has. The value of C_2, in terms of C_1, then

$U_s = U_p$

$\frac{1}{2}C_s(4V)^2 = \frac{1}{2}C_p V^2$

$\cancel{\frac{1}{2}}\frac{C_1}{n_1}16\cancel{V^2} = \cancel{\frac{1}{2}}n_2 C_2 \cancel{V^2}$

$\frac{16 C_1}{n_1 n_2} = C_2$

$U_s = \frac{Q^2}{2C_s} = \frac{1}{2}C_s V^2 = \frac{1}{2}QV$

A. $\frac{2C_1}{n_1 n_2}$

B. $16\frac{n_2}{n_1}C_1$

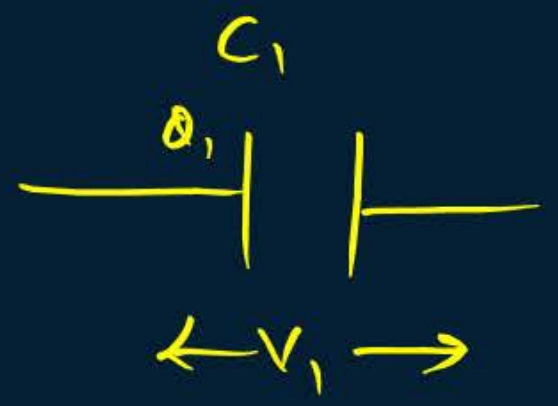
C. $2\frac{n_2}{n_1}C_1$

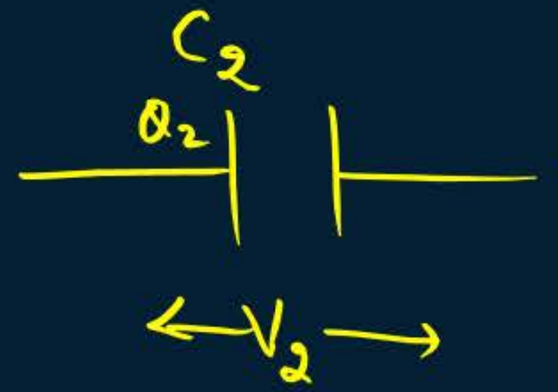
D. $\frac{16C_1}{n_1 n_2}$

Sharing of Charges and Common Potential

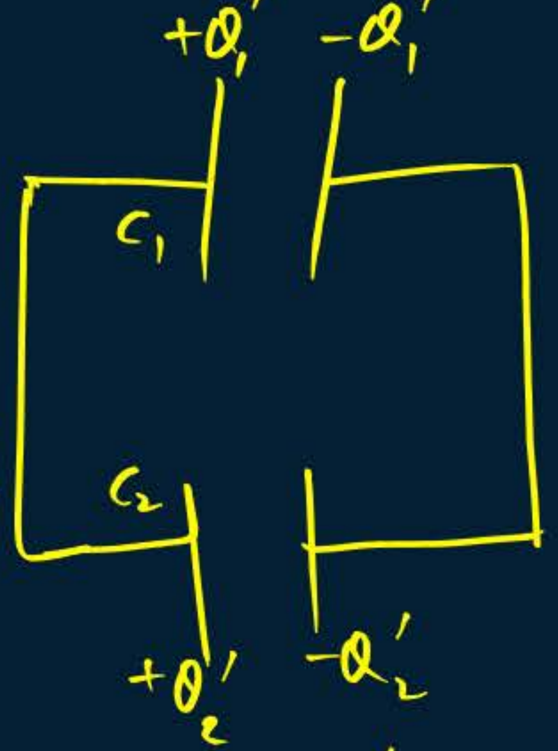
$Q = CV$

$\rightarrow V_{common} = ?$





Same polarity



Opposite Polarity $\Rightarrow$

$$\boxed{V_{common} = \frac{C_1V_1 - C_2V_2}{C_1 + C_2}}$$

By law of conservation of charge :-

initial charge before connection = final charge after connection

$$Q_1 + Q_2 = Q_1' + Q_2'$$

$$C_1V_1 + C_2V_2 = C_1V_c + C_2V_c$$

$$C_1V_1 + C_2V_2 = V_c(C_1 + C_2)$$

Common Potential $\leftarrow$ $\boxed{V_c = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$ $\Rightarrow$ Same Polarity

QUESTION

H.W.

A capacitor of capacity C_1 charged upto V volt and then connected to an uncharged capacitor of capacity C_2. The final potential difference across each will be

A) $\dfrac{C_2 V}{C_1 + C_2}$

B) $\dfrac{C_1 V}{C_1 + C_2}$

C) $\left(1 + \dfrac{C_2}{C_1}\right)$

D) $\left(1 - \dfrac{C_2}{C_1}\right) V$

QUESTION

H.W.

A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system

A increases by a factor of 4

B decreases by a factor of 2

C remains the same

D increases by a factor of 2

QUESTION

H.W.

A 3 μF capacitor is charged to a potential of 300 V and 2 μF capacitor is charged to 200 V. The capacitors are then connected in parallel with plates of opposite polarity joined together. Find the common potential after connecting.

A. 100 V

B. 200 V

C. 300 V

D. 400 V

Homework

- Notes
- Practice Ques
- DPP

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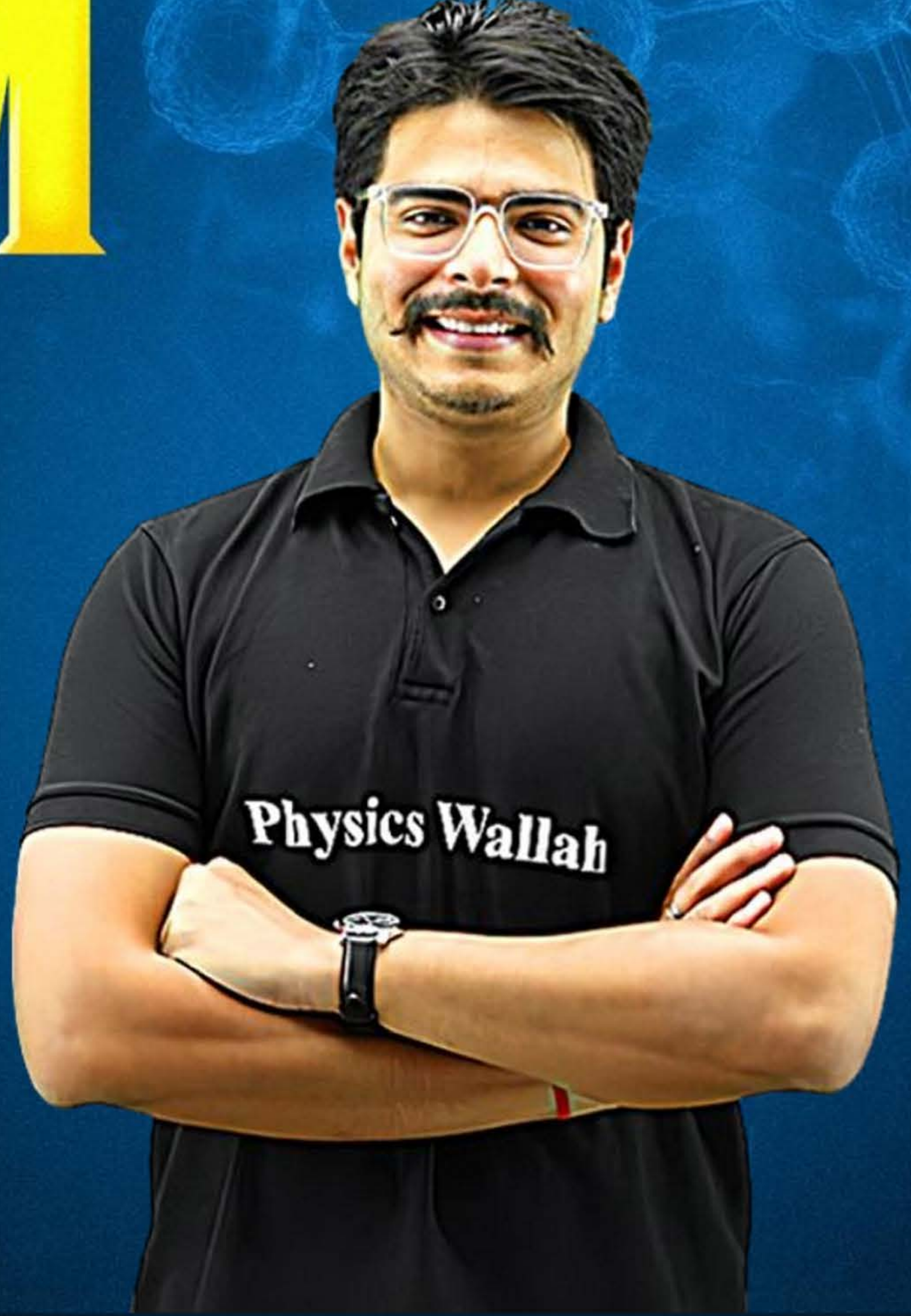
2026

Lecture - 09

Electrostatic Potential and Capacitance

PHYSICS **Lecture 09**

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Dielectrics ✓
- **B** Dielectrics inside Capacitor ✓
- **C**
- **D**
- **E**

HW QUESTION

A capacitor of capacity C_1 charged upto V volt and then connected to an uncharged capacitor of capacity C_2. The final potential difference across each will be

A $\dfrac{C_2V}{C_1+C_2}$

B $\dfrac{C_1V}{C_1+C_2}$

C $\left(1+\dfrac{C_2}{C_1}\right)$

D $\left(1-\dfrac{C_2}{C_1}\right)V$

$$V_c = \frac{C_1V_1 + C_2V_2}{C_1+C_2}$$

$$= \frac{C_1V + C_2(0)}{C_1+C_2} = \frac{C_1V}{C_1+C_2}$$

HW QUESTION

A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system

(A) increases by a factor of 4

(B) decreases by a factor of 2

(C) remains the same

(D) increases by a factor of 2

HW QUESTION

A 3 μF capacitor is charged to a potential of 300 V and 2 μF capacitor is charged to 200 V. The capacitors are then connected in parallel with plates of opposite polarity joined together. Find the common potential after connecting.

A 100 V

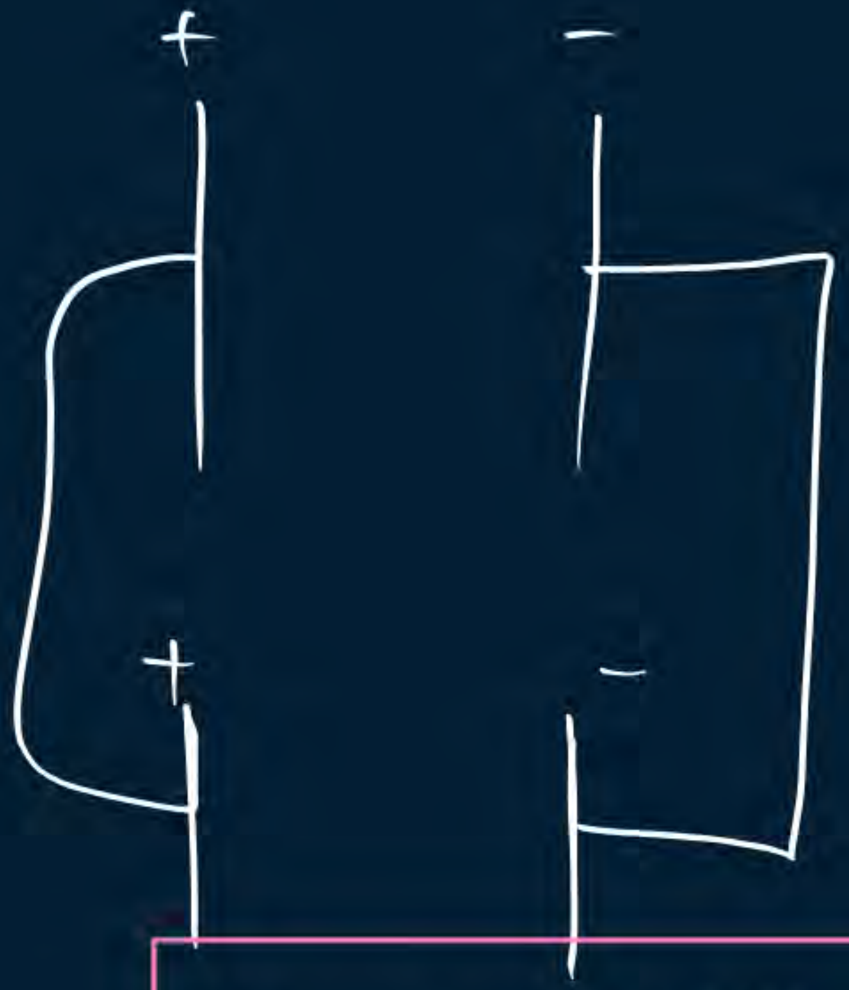
B 200 V

C 300 V

D 400 V

$$V_c = \frac{C_1V_1 - C_2V_2}{C_1+C_2} = \frac{3\times300 - 2\times200}{3+2}$$

$$= \frac{900-400}{5} = \frac{\cancel{500}^{100}}{\cancel{5}}$$

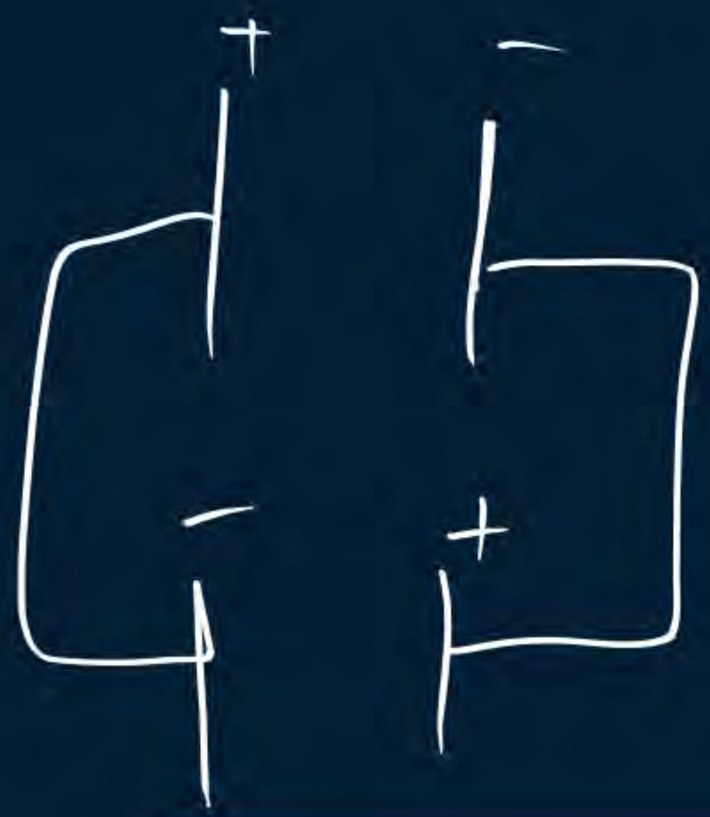


$$V_c = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

याद *

$$\Delta U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 - V_2)^2$$

Loss of Heat

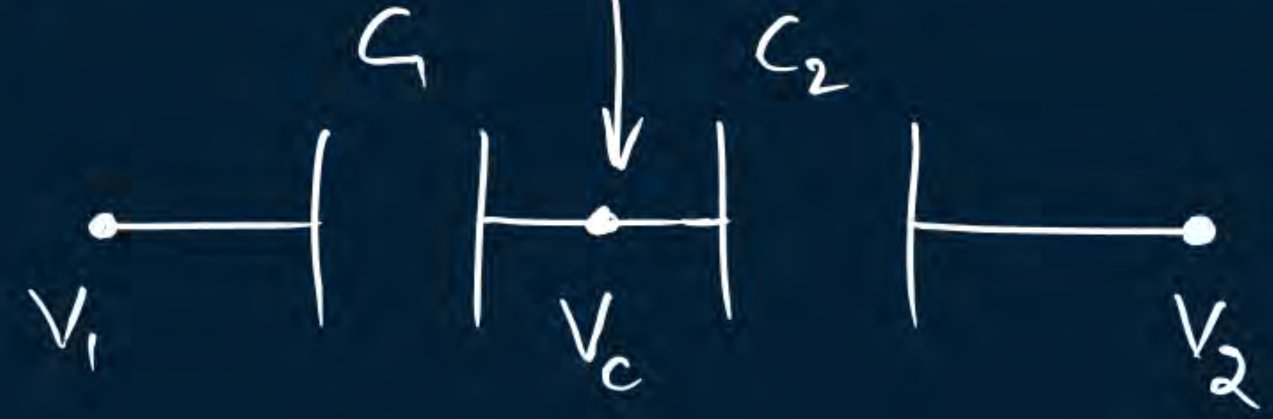


$$V_c = \frac{C_1V_1 - C_2V_2}{C_1 + C_2}$$

$$\Delta U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 + V_2)^2$$

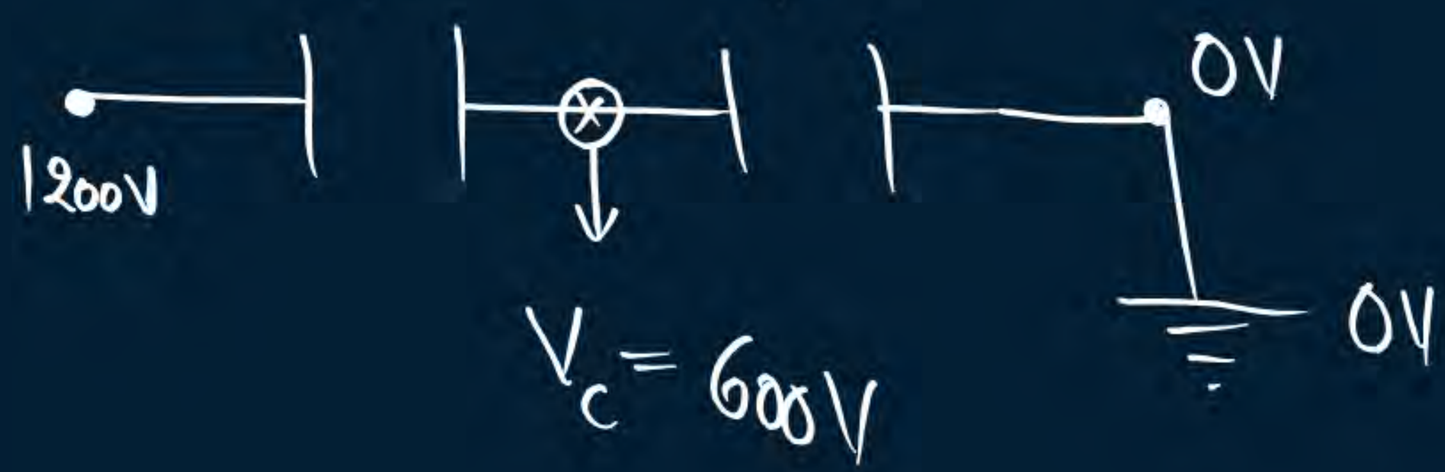
Loss of Heat

Junction Potential in Capacitors



$$\boxed{V_c = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

Ques

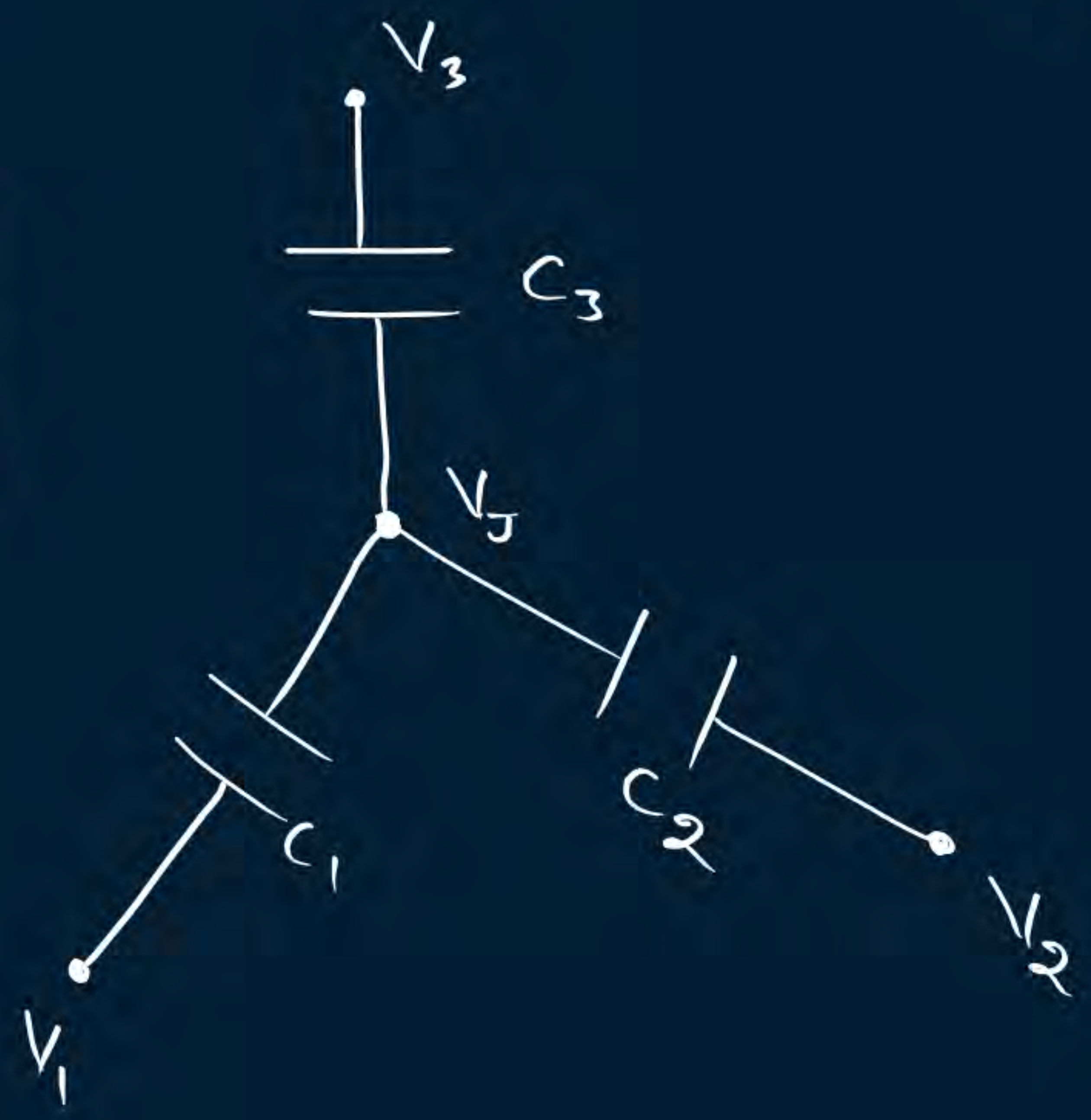


$$V_c = \frac{3 \times 1200 + 3 \times 0}{3+3}$$

$$= \frac{\cancel{3600}}{\cancel{6}} \; 600V$$

Three Terminal Junction

$$\boxed{V_J = \frac{C_1V_1 + C_2V_2 + C_3V_3}{C_1 + C_2 + C_3}}$$



Dielectrics

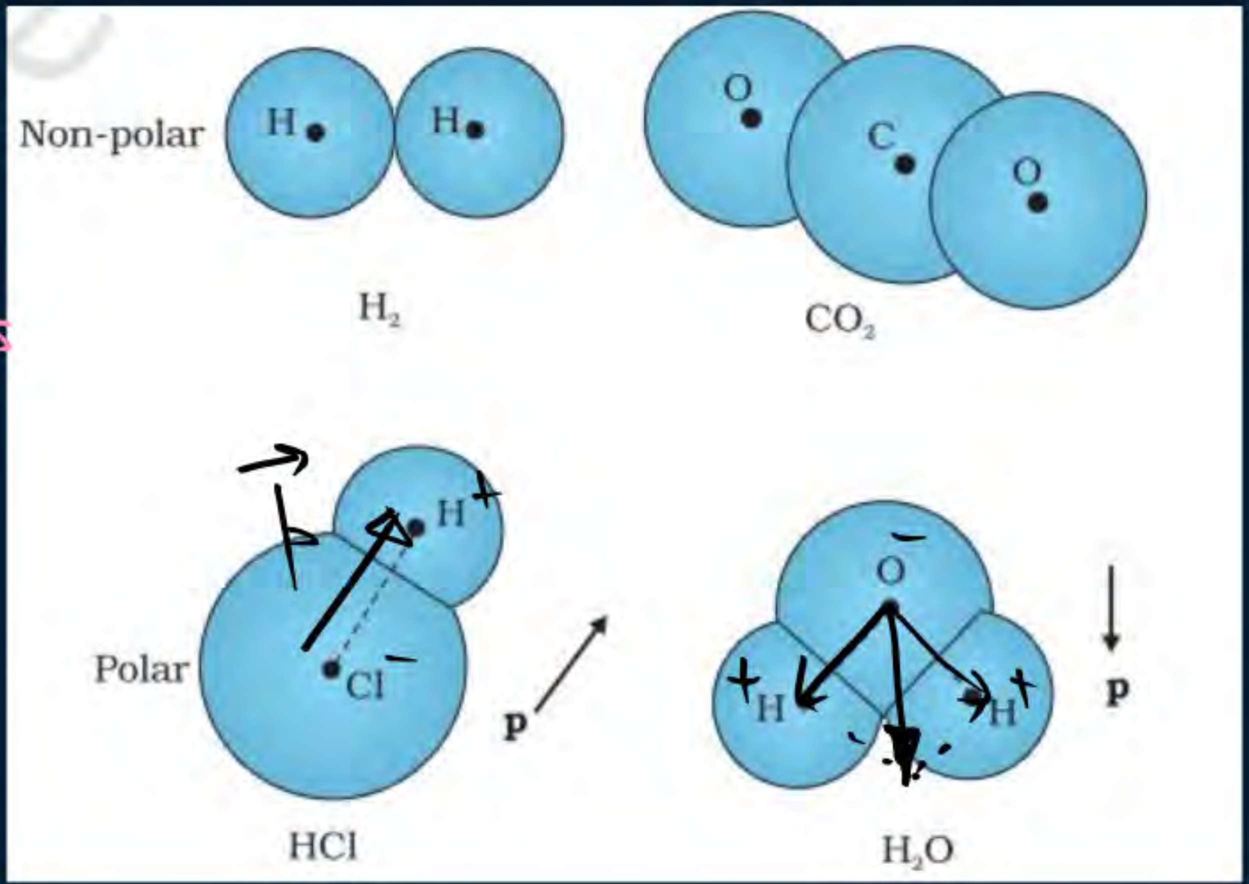
Dielectrics are the insulators which transfer electrical effects without conduction. Eg- mica, glass, plastic etc.

Polar Dielectrics

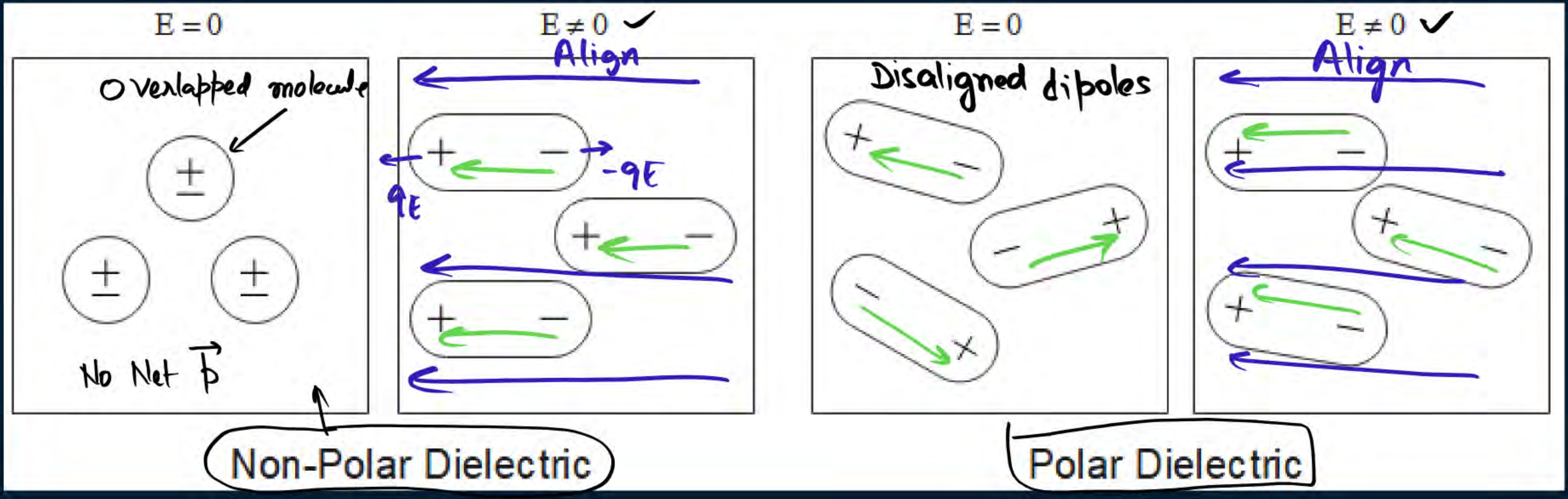
Natural dipole moment

Non-polar Dielectrics

No Natural $\vec{p}$



Polarization of Dielectrics (Non-Polar & Polar)



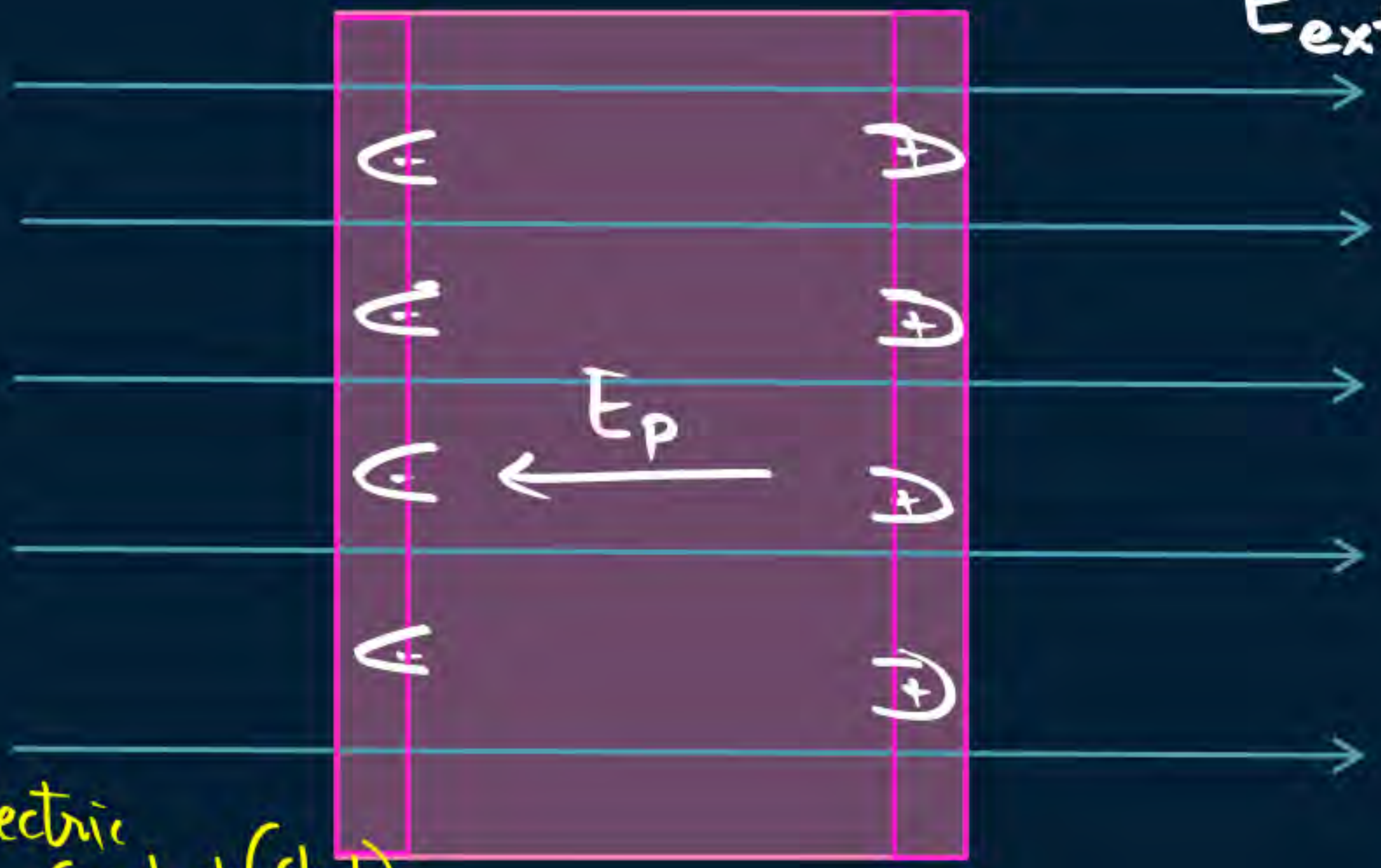
Induced Electric Field in Dielectrics

Y.K.B.

E_{ext} - External E.F.

E_p - Polarised E.F.

$$\boxed{E_{net} = E_{ext} - E_p}$$



*
$$\boxed{E_{net} = \frac{E_{ext}}{K}}$$

K → Dielectric Constant (ch-1)

NOTE - Net EF inside the dielectric is $\frac{1}{K}$ times the Ext. EF.

In Case of Conductor

$E_{net} = E_{ext} - E_p$

We know that,

$|E_p| = |E_{ext}|$

$E_{net} = E_{ext} - E_{ext}$

$$\boxed{E_{net} = 0}$$

$E_{net} = \frac{E_{ext}}{K} = \frac{E_{ext}}{\infty} = 0$

for Conductors → $K = \infty$

Polarization

$\vec{P}$

Polarisation = $\dfrac{\text{Dipole moment}}{\text{Volume}}$

Polarization is defined as the Net Dipole Moment per unit volume

Its magnitude is called Polarization Density $|\vec{P}|$

its direction is Same as that of Electric Field

$$\boxed{\vec{P} = \frac{\vec{p}}{\text{Vol.}}}$$

$\vec{E}$

$\vec{P}$

Polarisation Density & Electric Susceptibility (χ)

$\hookrightarrow$ Chi

or

Surface charge density (σ_p)

$$\boxed{|\vec{P}| = \sigma_p = \frac{Q}{A}}$$

ratio of the polarisation to ϵ_0 times the Electric field.

$$\boxed{\chi = \frac{P}{\epsilon_0 E_{net}}}$$

Relation between Dielectric Constant (K) and Electric Susceptibility (χ)

$K = 1 + \chi$

concept !!!

$E_{net} = \frac{E_{ext}}{K}$

$$\boxed{K = \frac{E_{ext}}{E_{net}}}$$

$$E_{net} = E_{ext} - E_p$$

We know that, $E_p = \frac{\sigma_p}{\epsilon_0} = \frac{|\vec{P}|}{\epsilon_0}$

$$E_{net} = E_{ext} - \frac{|\vec{P}|}{\epsilon_0}$$

Using, $\chi = \frac{P}{\epsilon_0 E_{net}}$, $P = \chi \epsilon_0 E_{net}$

$$E_{net} = E_{ext} - \frac{\chi \cancel{\epsilon_0} E_{net}}{\cancel{\epsilon_0}}$$

$$E_{net} = E_{ext} - \chi E_{net}$$

Divide by E_{net} both sides...

$$\frac{\cancel{E_{net}}}{\cancel{E_{net}}} = \frac{E_{ext}}{E_{net}} - \frac{\chi \cancel{E_{net}}}{\cancel{E_{net}}},$$

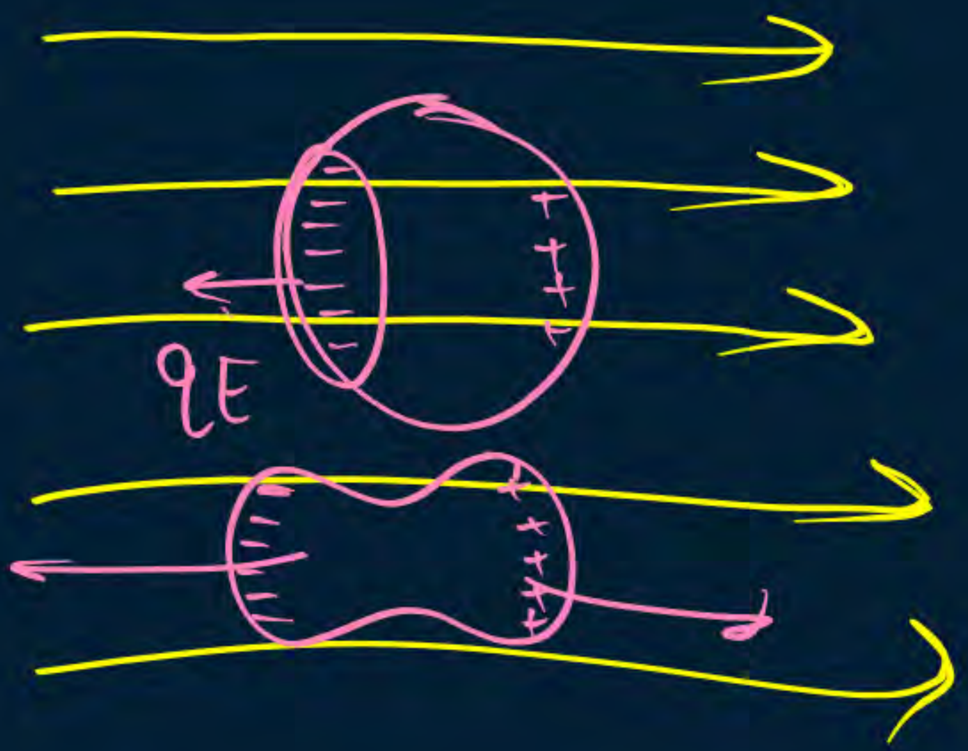
$$1 = K - \chi$$

4IQ

$$\boxed{K = 1 + \chi}$$

Dielectric Strength

Maximum Electric Field in a Dielectric without breaking of its insulating property



Dielectric Breakdown of Air molecules.

Dielectric breakdown in air occurs when a strong electric field causes the air to suddenly become conductive, allowing current to flow. This happens when the electric field strength exceeds the dielectric strength of air, which is about 30 kV/cm. This breakdown is often accompanied by sparks cause lightening

(charge due to Polarisation)

Magnitude of Induced Charges

$$E_{net} = E_{ext} - E_p$$

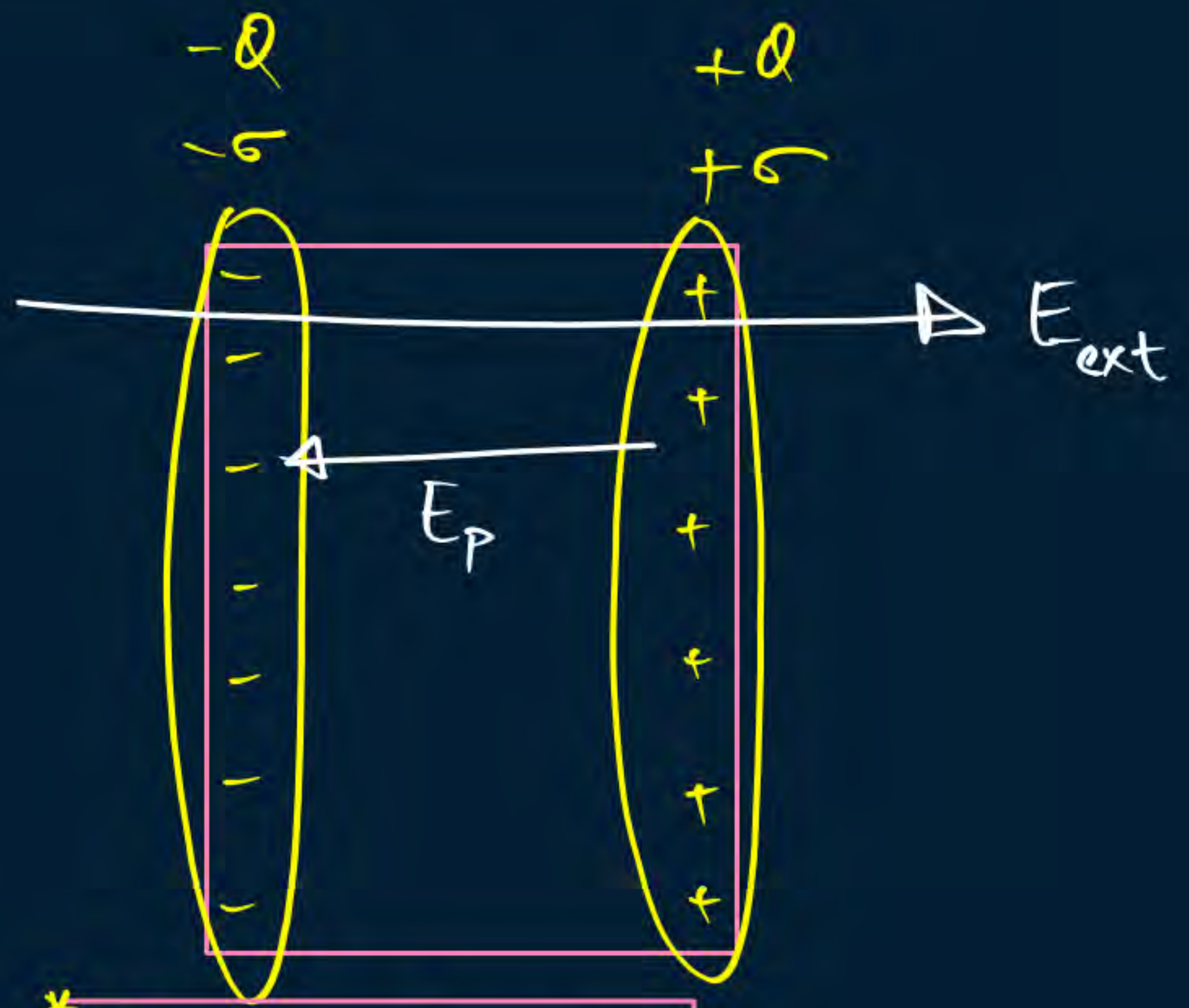
$$E_p = E_{ext} - E_{net}$$

$$E_p = E_{ext} - \frac{E_{ext}}{K}$$

$$E_p = E_{ext}\left(1 - \frac{1}{K}\right)$$

$$\frac{\sigma_p}{\epsilon_0} = \frac{\sigma_{ext}}{\epsilon_0}\left(1 - \frac{1}{K}\right)$$

$$\frac{Q_p}{\cancel{A\epsilon_0}} = \frac{Q_{ext}}{\cancel{A\epsilon_0}}\left(1 - \frac{1}{K}\right)$$



$$* \boxed{Q_p = Q_{net}\left(1 - \frac{1}{k}\right)}$$

$$E_{net} = \frac{E_{ext}}{K}$$

QUESTION

Charge on the capacitor is q. Now a mica sheet of dielectric constant $K=5$ is introduced in it. Find induced charge in the capacitor.

A $4q/5$

B $q/5$

C $5q/4$

D $5q$

$$Q_p = Q_{net}\left(1-\frac{1}{K}\right)$$

$$Q_p = q\left(1-\frac{1}{5}\right)$$

$$= \frac{4q}{5}$$

Homework

Notes ✓

Revision ✓

DPP

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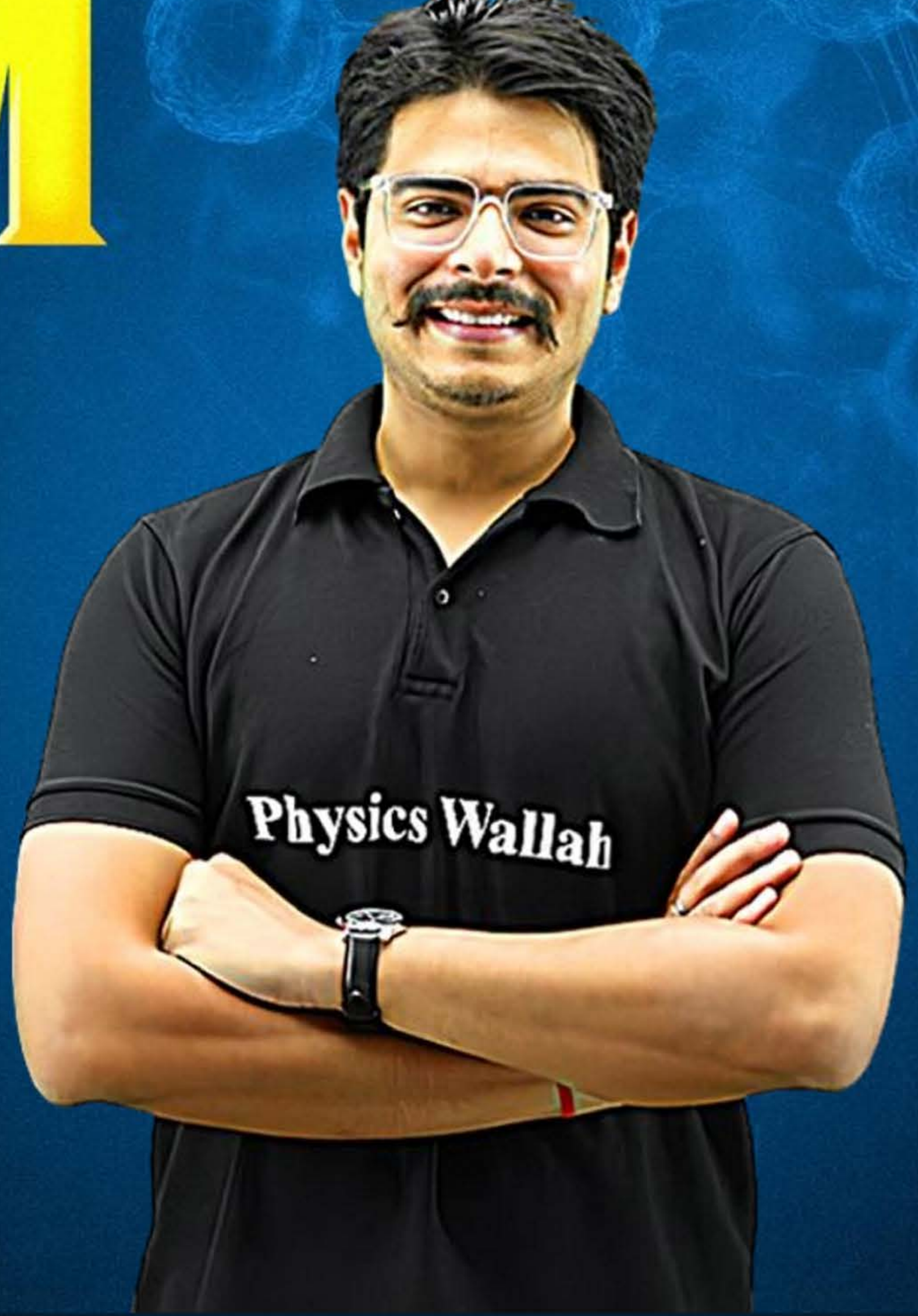
2026

Lecture - 10

Electrostatic Potential and Capacitance

PHYSICS Lecture 10

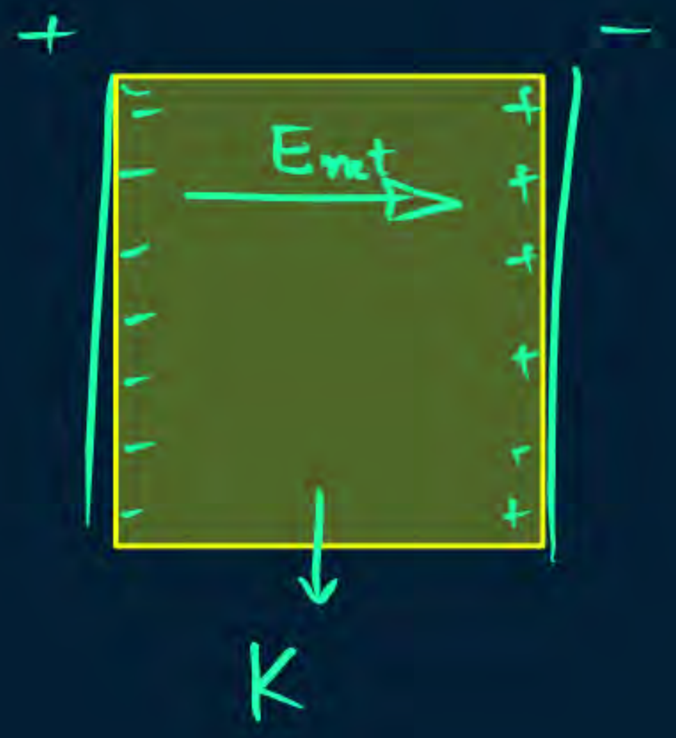
BY - RAKSHAK SIR



Topics *to be covered*

- **A**
- **B** Dielectrics inside Capacitor
- **C**
- **D**
- **E**

Effect of Dielectric on Capacitance



initially

① $C = \frac{\epsilon_0 A}{d}$

② $E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$

After insertion of Di-electric

① $C' = \frac{K\epsilon_0 A}{d}$

$\boxed{C' = KC}$

② $E' = \frac{Q}{AK\epsilon_0} = \frac{1}{K}\left(\frac{Q}{A\epsilon_0}\right)$

$\boxed{E' = \frac{E}{K}}$

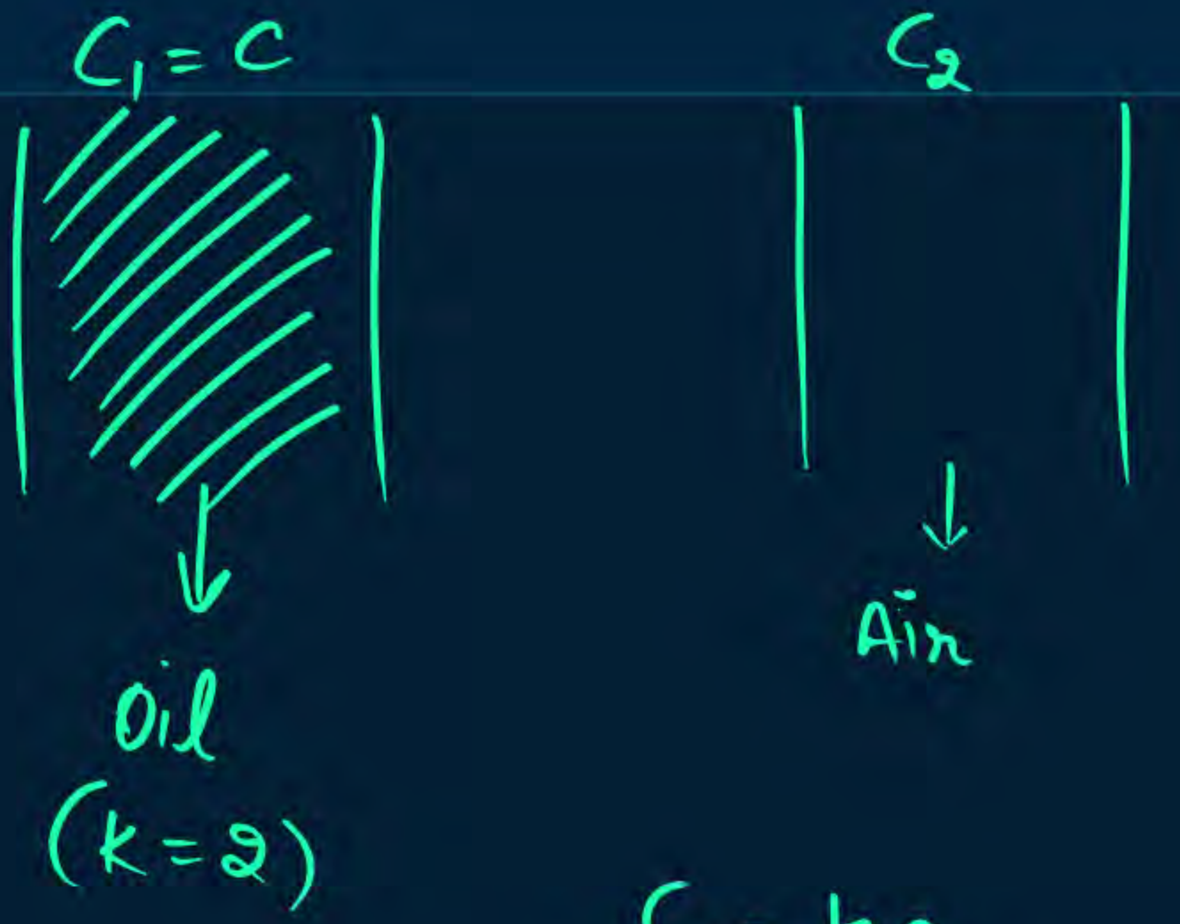
Y.K.B. $E_{net} = \frac{E_{ext}}{K}$

$\boxed{\text{C will increase}}$ by a factor of 'K'

$\boxed{\text{E is decreased}}$ by a factor of 'K'

QUESTION

A parallel plate condenser with oil between the plates (dielectric constant of oil $k = 2$ has a capacitance C. If the oil is removed, then capacitance of the capacitor becomes



(A) $C/\sqrt{2}$

(B) $2\,C$

(C) $\sqrt{2}C$

(D) $C/2$

$C_1 = kC_2$

$C = 2\,C_2$

$\frac{C}{2} = C_2$ Ans

QUESTION

The capacitance of a parallel plate capacitor with air as medium is $6\ \mu F$. With the introduction of a dielectric medium, the capacitance becomes $30\ \mu F$. The permittivity of the medium is : ($\epsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$)

(A) $0.44 \times 10^{-10}\ C^2\ N^{-1}\ m^{-2}$

(B) $5.00\ C^2\ N^{-1}\ m^{-2}$

(C) $0.44 \times 10^{-23}\ C^2\ N^{-1}\ m^{-2}$

(D) $1.77 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

$\boxed{\epsilon = K\epsilon_0}$

$= 5 \times \epsilon_0$

$\epsilon = \boxed{}$

$C = 6\mu F$

$C' = 30\mu F$

$C' = KC$

$\cancel{30}^{5}\ \cancel{\mu F} = K\ \cancel{6}^{1}\cancel{\mu F}$

$K = 5$

Imp.

Effect of Dielectric on Different Variables

$C \uparrow$

$Q \rightarrow$ same

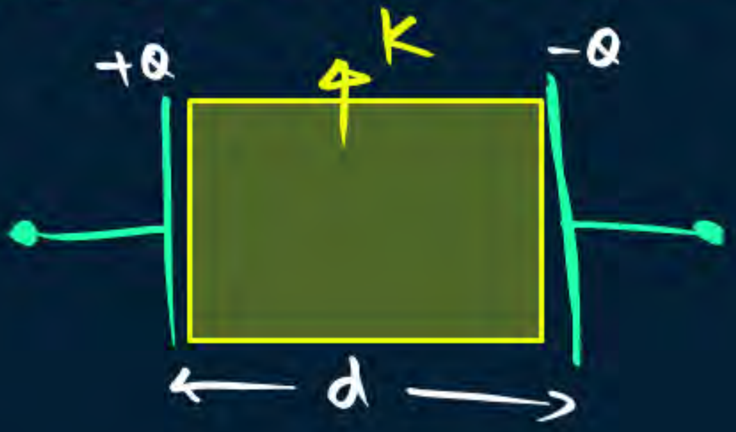
$E \downarrow$

$V \downarrow$

$U \downarrow$

lonely...

A) Battery not connected (Isolated Capacitor)



1. $C = \frac{\epsilon_0 A}{d}$

$C' = K\left(\frac{\epsilon_0 A}{d}\right)$

$\boxed{C' = KC}$

2. Q remains same

$\boxed{Q' = Q}$

3. $E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$

$E' = \frac{Q}{AK\epsilon_0} = \frac{1}{K}\left(\frac{Q}{A\epsilon_0}\right)$

$\boxed{E' = \frac{E}{K}}$

4. $V = E \cdot d$

$V' = E'd$

$V' = \left(\frac{E}{K}d\right)$

$\boxed{V' = \frac{V}{K}}$

5. $U = \frac{Q^2}{2C}$

$U' = \frac{Q^2}{2C'}$

$U' = \frac{1}{K}\left(\frac{Q^2}{2C}\right)$

$\boxed{U' = \frac{U}{K}}$

B) Battery connected (Isolated Capacitor)

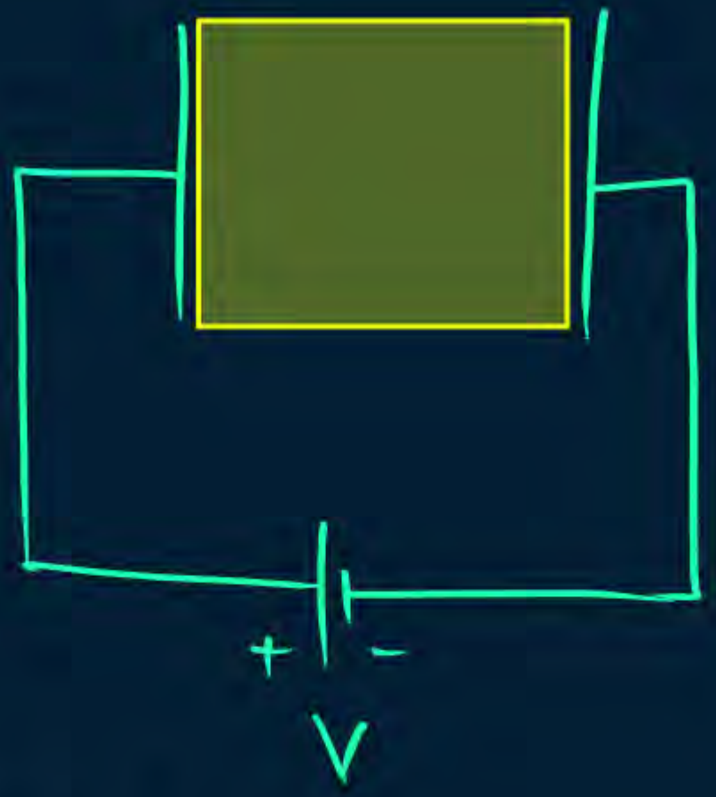
$C \uparrow$

$Q \uparrow$

$E \rightarrow$ same

$V \rightarrow$ same

$U \uparrow$



1.) $C = \dfrac{\epsilon_0 A}{d}$

$C' = K\left(\dfrac{\epsilon_0 A}{d}\right)$

$\boxed{C' = KC}$

2.) Battery is connected

$\boxed{V' = V}$ → remains same

3.) $Q = CV$

$Q' = C'V$

$Q' = K(CV)$

$\boxed{Q' = KQ}$

4.) $V = E \cdot d$

$\boxed{E' = E}$ → remains same

5.) $U = \dfrac{1}{2} CV^2$

$U' = \dfrac{1}{2} C' V^2$

$= \dfrac{1}{2} KCV^2 = K\left(\dfrac{1}{2} CV^2\right)$

$\boxed{U' = KU}$

QUESTION

Two parallel metal plates having charges +Q and –Q face each other at a certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

RDx NOTE :- if Not given, choose I always

(Battery disconnected)

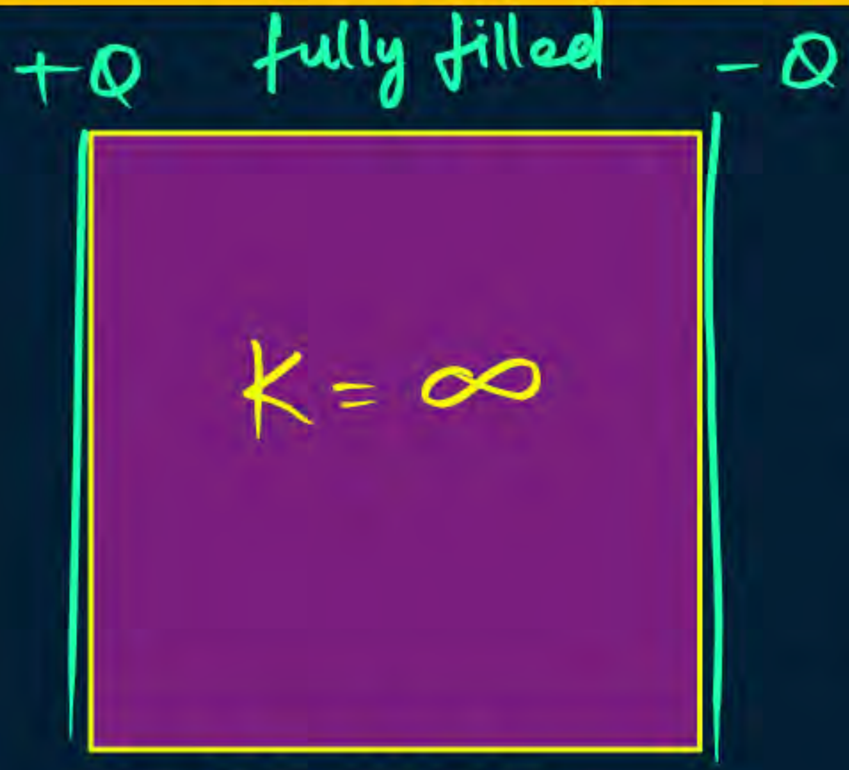
A become zero

B increase

C decrease

D remain same

Capacitor partially filled with conducting slab



$$C = \epsilon_0 A / d$$

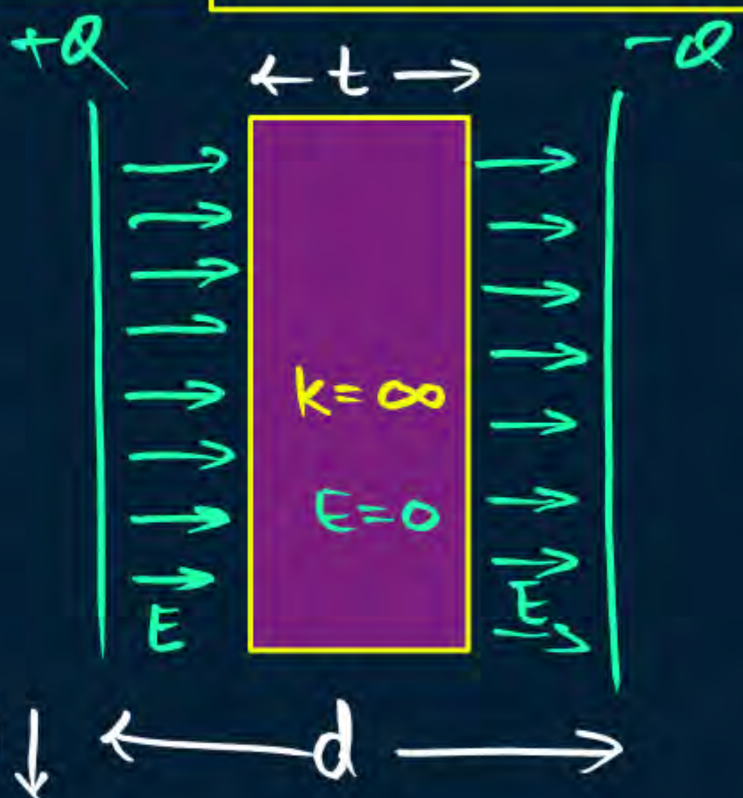
$$C' = \frac{K\epsilon_0 A}{d}$$

$$C = \infty \frac{\epsilon_0 A}{d}$$

$$C \to \infty$$

$$C = \frac{\epsilon_0 A}{d}$$

$$C\uparrow = \frac{\epsilon_0 A}{(d-t)\downarrow}$$



$$V = Ed$$

$$V = E(d-t) + 0 \times t$$

$$V = E(d-t)$$

$$V = \frac{\sigma}{\epsilon_0}(d-t)$$

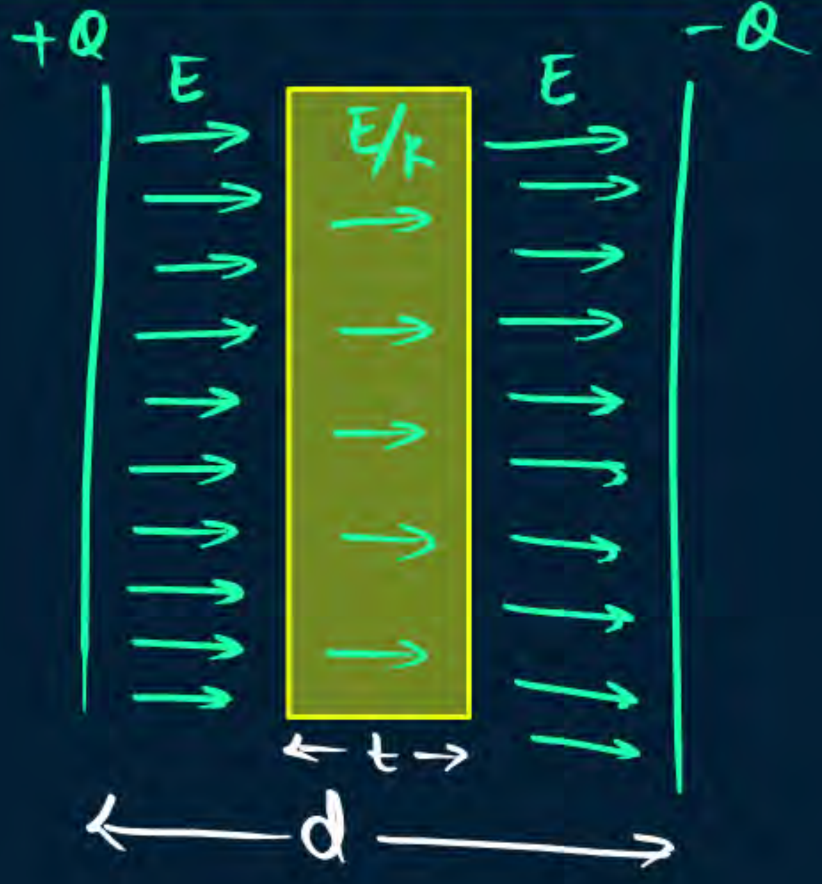
$$V = \frac{Q}{A\epsilon_0}(d-t)$$

$$Q = CV$$

$$C = \frac{Q}{V} = \frac{\cancel{Q}}{\frac{\cancel{Q}}{A\epsilon_0}(d-t)}$$

$$* \quad \boxed{C = \frac{\epsilon_0 A}{(d-t)}}$$

Capacitor partially filled with dielectric slab



$$Q = CV$$

$$C = \frac{Q}{V}$$

$$= \frac{\cancel{Q}}{\frac{\cancel{Q}}{A\epsilon_0}\left(d - t + \frac{t}{K}\right)}$$

$$* \quad \boxed{C = \frac{\epsilon_0 A}{\left(d - t + \frac{t}{K}\right)}}$$

$$V = Ed$$

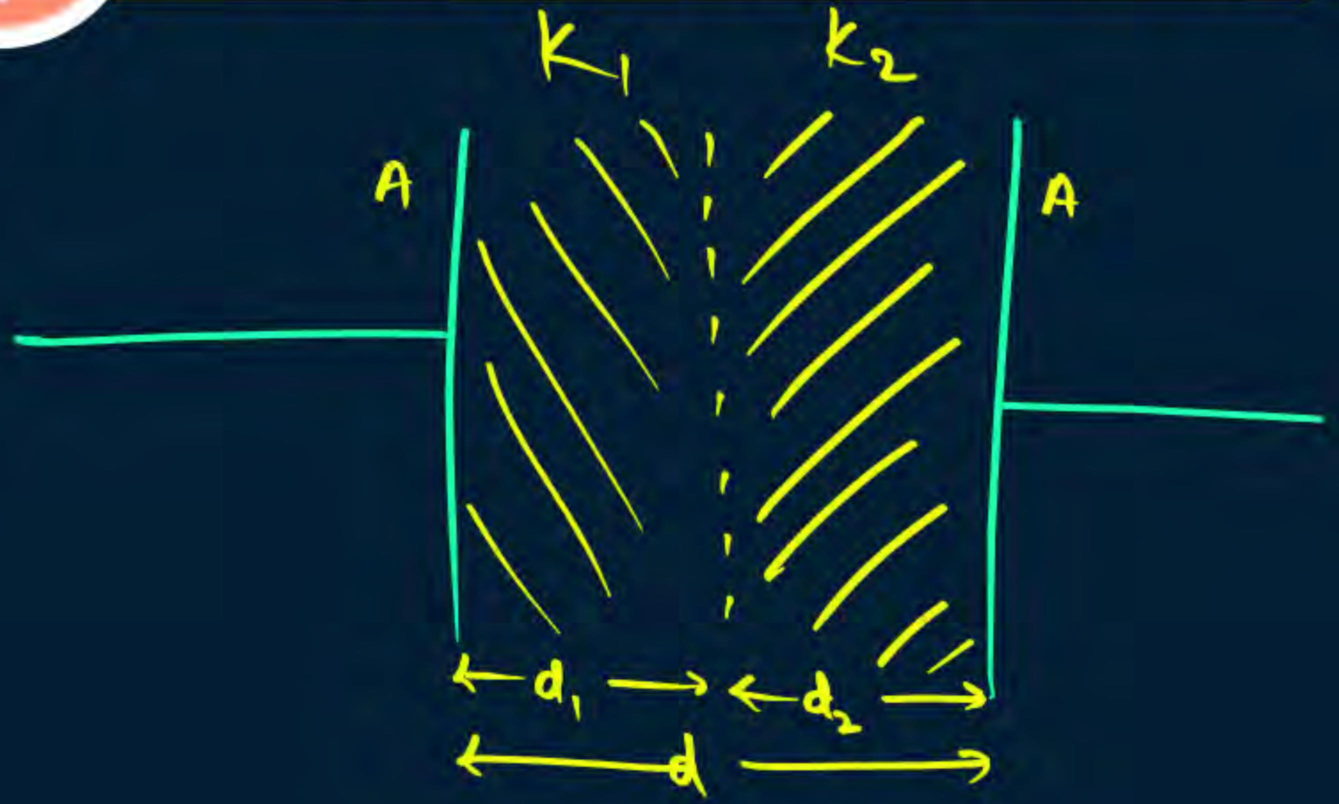
$$V = E(d-t) + \frac{E}{K}t$$

$$V = E\left(d - t + \frac{t}{K}\right)$$

$$V = \frac{\sigma}{\epsilon_0}\left(d - t + \frac{t}{K}\right)$$

$$V = \frac{Q}{A\epsilon_0}\left(d - t + \frac{t}{K}\right)$$

Series Combination



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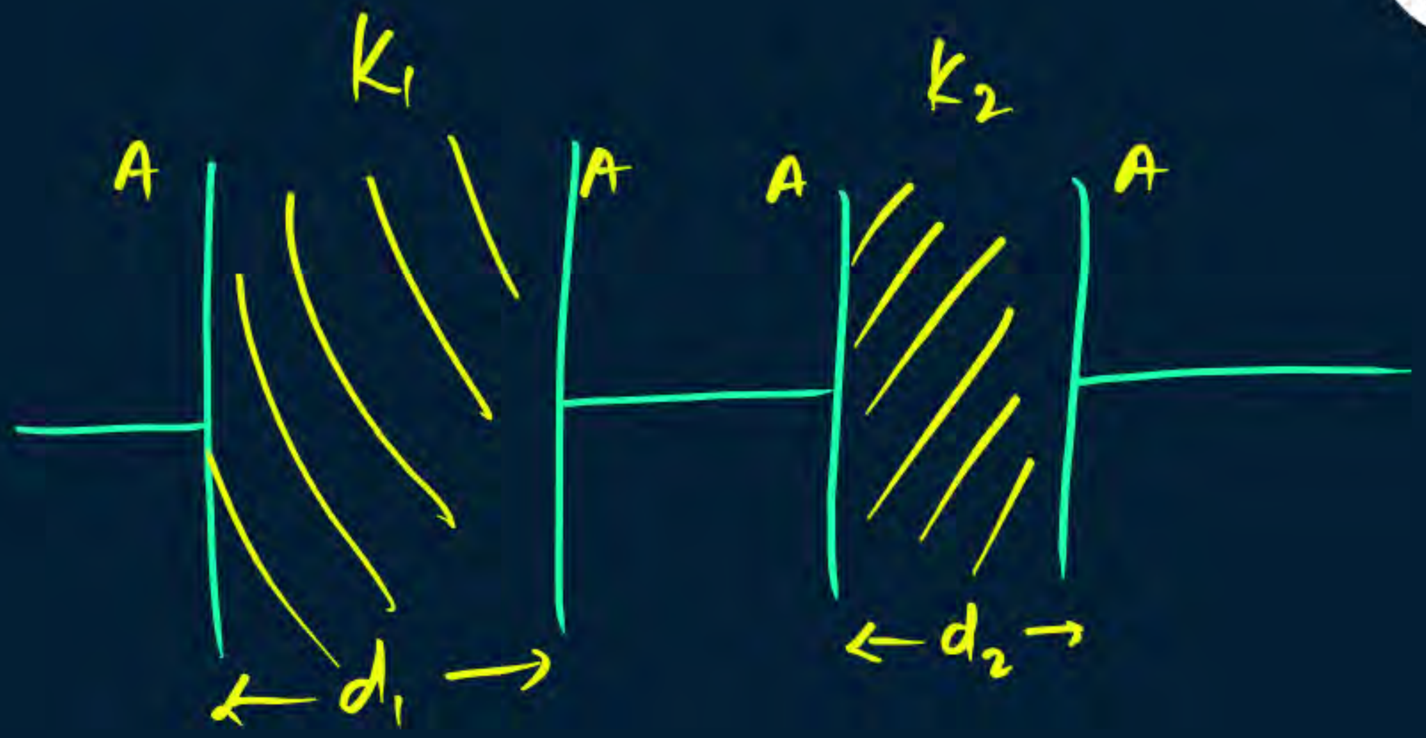

$$C_1 = \frac{K_1 \epsilon_0 A}{d_1} \qquad C_2 = \frac{K_2 \epsilon_0 A}{d_2}$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_s} = \frac{1}{\frac{K_1 \epsilon_0 A}{d_1}} + \frac{1}{\frac{K_2 \epsilon_0 A}{d_2}} \Rightarrow \frac{1}{C_s} = \frac{1}{\epsilon_0 A}\left[\frac{d_1}{K_1} + \frac{d_2}{K_2}\right]$$

$$\frac{1}{C_s} = \frac{\left[\frac{d_1}{k_1}+\frac{d_2}{k_2}\right]}{\epsilon_0 A}$$

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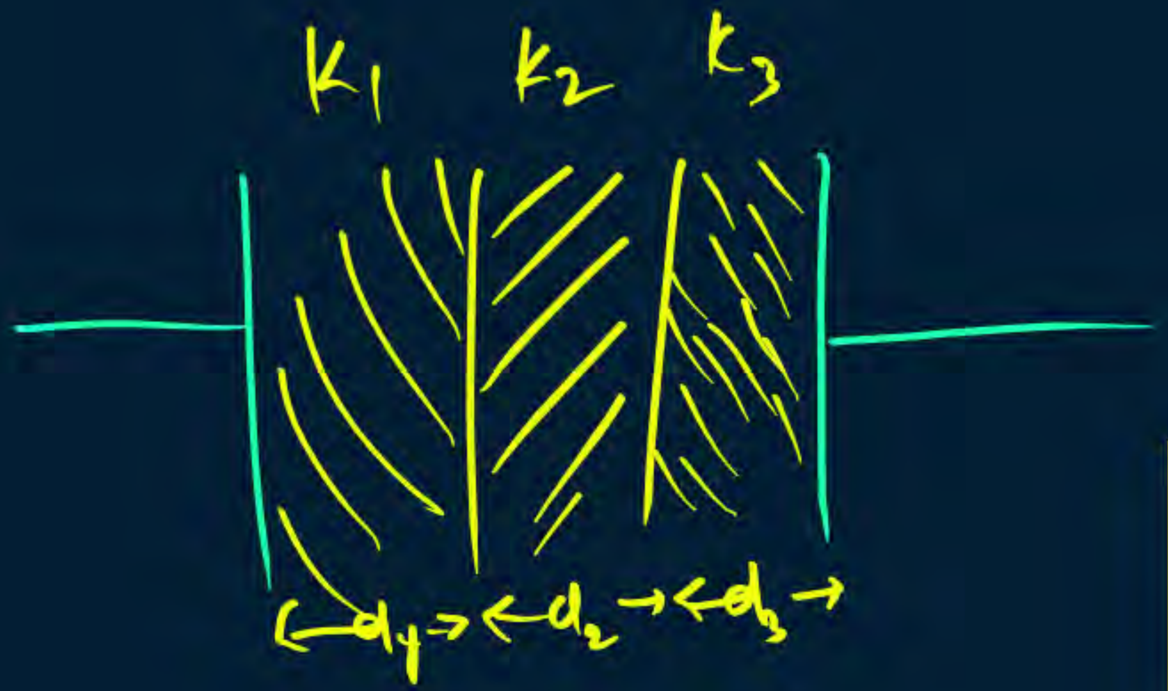
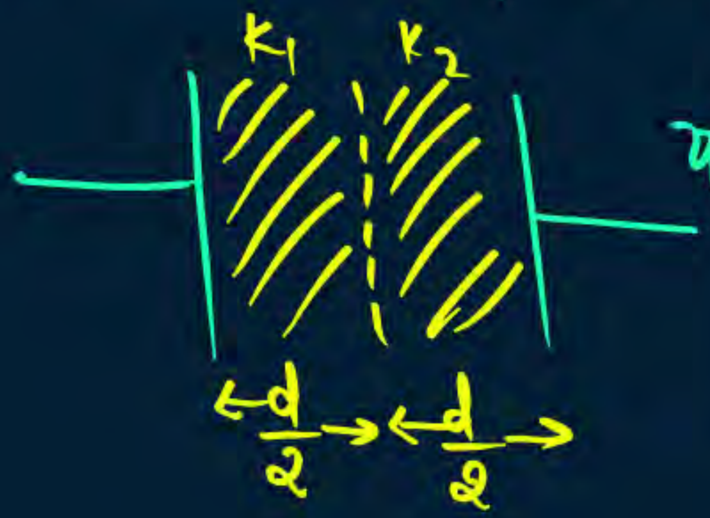
$$\boxed{C_s = \frac{\epsilon_0 A}{\frac{d_1}{k_1}+\frac{d_2}{k_2}}}$$



$$\boxed{C_s = \frac{\epsilon_0 A}{\frac{d_1}{k_1}+\frac{d_2}{k_2}+\frac{d_3}{k_3}\cdots}}$$

RDx Case :-

2 identical capacitors.



याद

$$\boxed{C_s = \frac{\epsilon_0 A}{d}\,\frac{2K_1K_2}{(K_1+K_2)}} \Rightarrow \boxed{C_s = C\left(\frac{2K_1K_2}{K_1+K_2}\right)}$$

QUESTION

Two dielectric slabs of constant K_1 and K_2 have been filled in between the plates of a capacitor as shown below each occupying half of the space. What will be the capacitance of the capacitor?

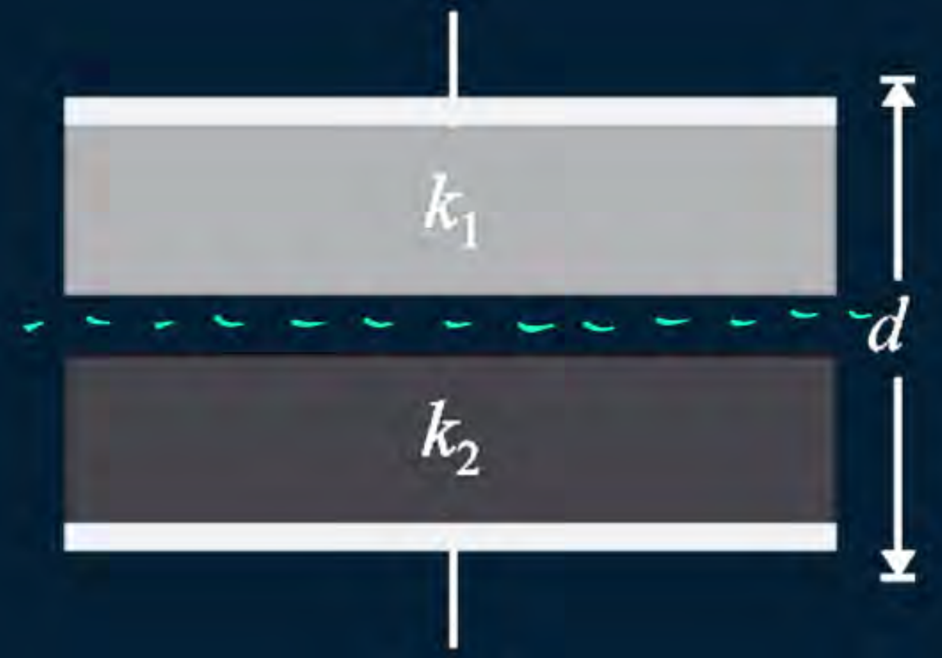
(A) $\frac{2\varepsilon_0 A}{d}(K_1 + K_2)$

(B) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1 + K_2}{K_1 \times K_2}\right)$

(C) $\frac{\varepsilon_0 A}{2d}\left(\frac{K_1 \times K_2}{K_1 + K_2}\right)$

(D) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1 \times K_2}{K_1 + K_2}\right)$

$C_s = \frac{\epsilon_0 A}{d} \frac{2K_1K_2}{(K_1+K_2)}$



QUESTION

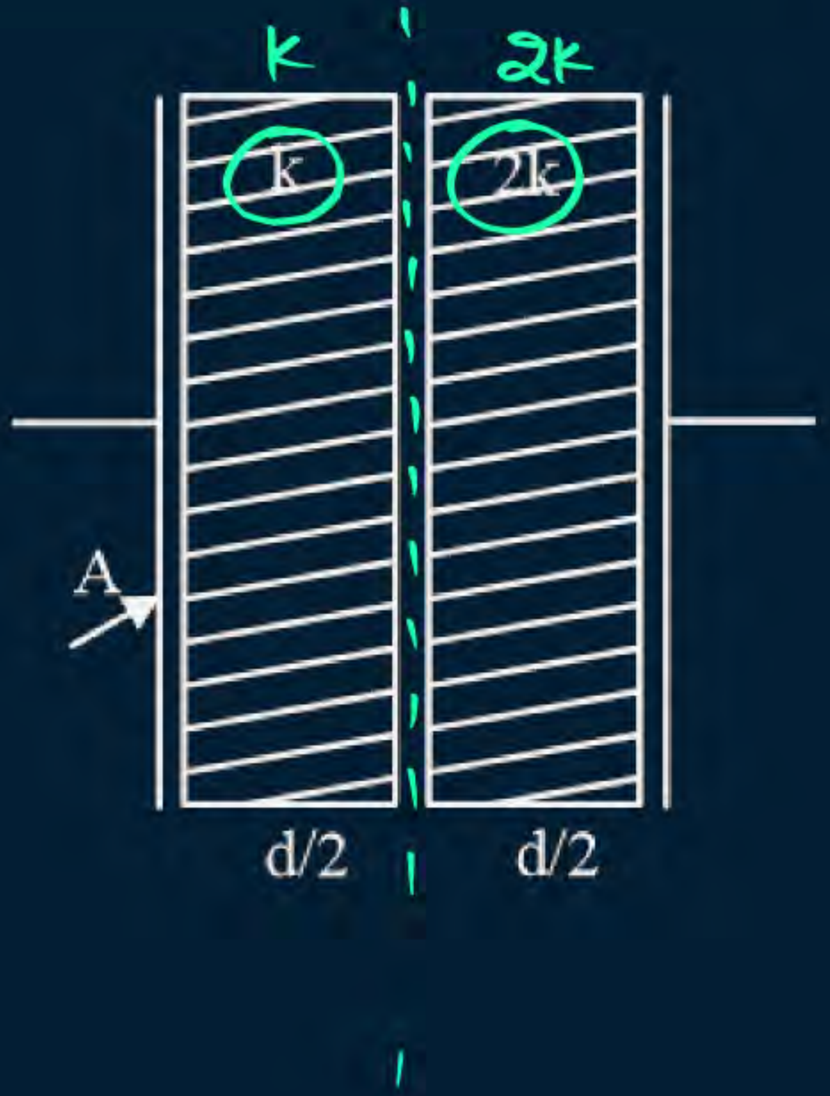
Find the capacitance of the given arrangement.

$$C_s = \frac{\epsilon_0 A}{d} \frac{2K_1K_2}{K_1+K_2}$$

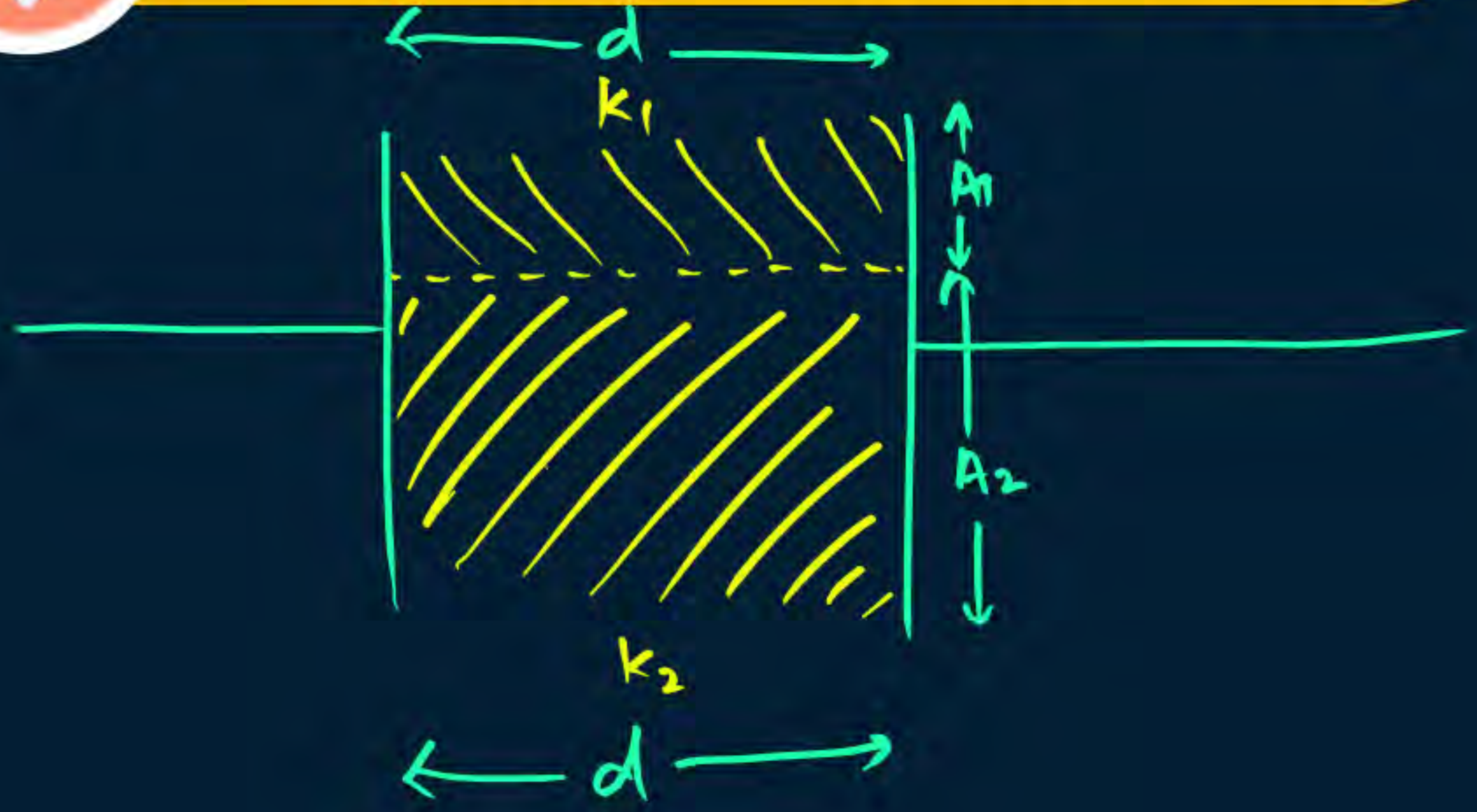
$$= \frac{\epsilon_0 A}{d} \frac{2K\,2K}{K+2K}$$

$$= \frac{\epsilon_0 A}{d} \frac{4K^{\cancel{2}}}{3\cancel{K}}$$

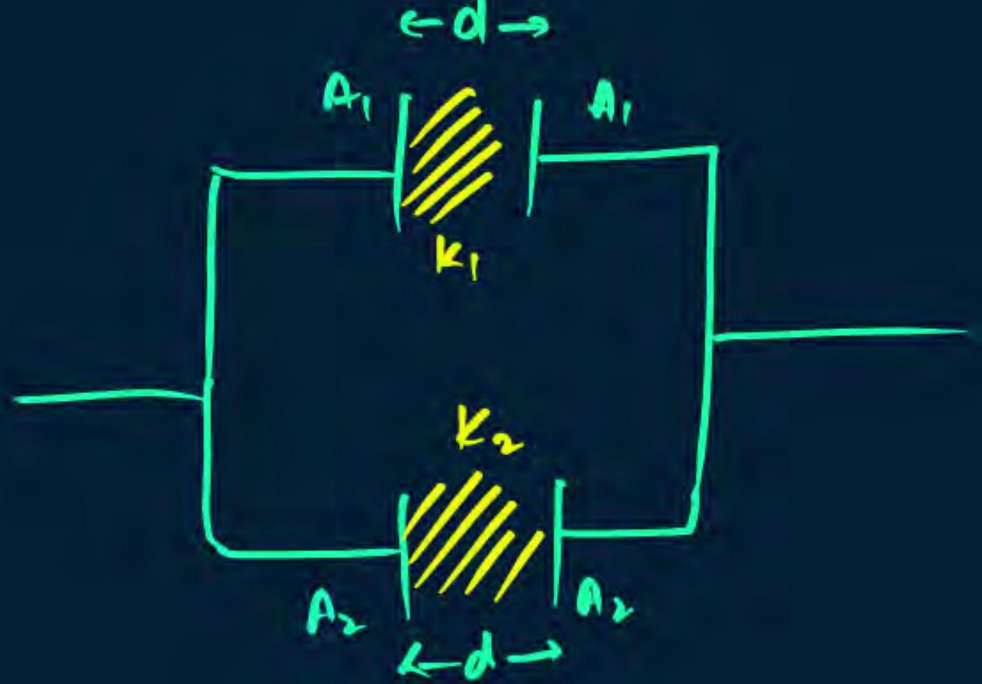
$$= \frac{4}{3}K\frac{\epsilon_0 A}{d} \quad \underline{\underline{\text{Ans}}}$$



Parallel Combination



$\equiv$



$$C_1 = \frac{k_1 \epsilon_0 A_1}{d}$$

$$C_2 = \frac{k_2 \epsilon_0 A_2}{d}$$

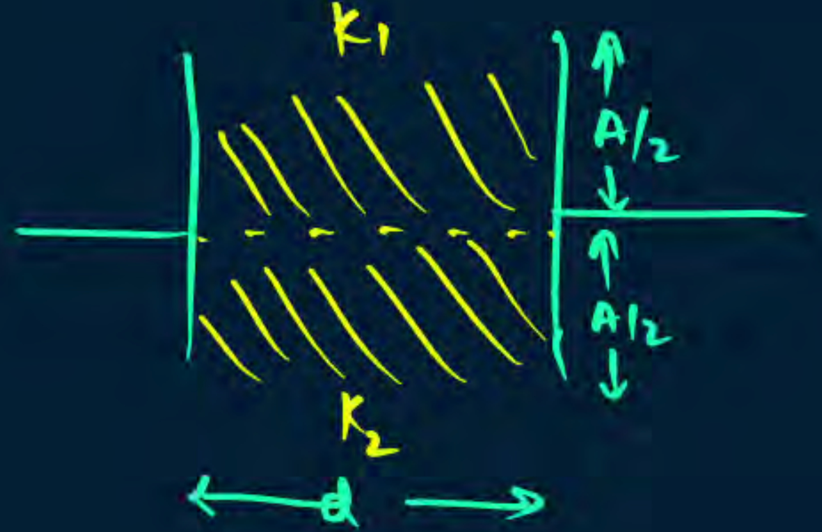
$$C_p = C_1 + C_2$$

$$= \frac{k_1 \epsilon_0 A_1}{d} + \frac{k_2 \epsilon_0 A_2}{d}$$

याद

$$\boxed{C_p = \frac{\epsilon_0}{d}\left(k_1 A_1 + k_2 A_2\right)}$$

RDx Case



$$C_p = \frac{\epsilon_0}{d}\left(K_1A_1 + K_2A_2\right)$$

$$C_p = \frac{\epsilon_0}{d}\left(K_1\frac{A}{2} + K_2\frac{A}{2}\right)$$

$$= \frac{\epsilon_0 A}{2d}\left(K_1 + K_2\right)$$

याद

$$\boxed{C_p = \frac{\epsilon_0 A}{d}\left(\frac{K_1+K_2}{2}\right)}$$

$$C_p = C\left(\frac{K_1+K_2}{2}\right)$$

QUESTION

A parallel plate capacitor with air as medium between the plates has a capacitance of 10μF. The area of capacitor is divided into two equal halves and filled with two media as shown in the figure dielectric constant $k_1 = 2$ and $k_2 = 4$. The capacitance of the system will now be

(A) 10 μF

(B) 20 μF

(C) 30 μF

(D) 40 μF

$C = 10\mu F$

$$C_p = C\left(\frac{k_1 + k_2}{2}\right)$$

$$C_p = 10\left(\frac{2+4}{2}\right)$$

$$= 10 \times \frac{\cancel{6}^{\,3}}{\cancel{2}}$$

$$= 30\mu F$$

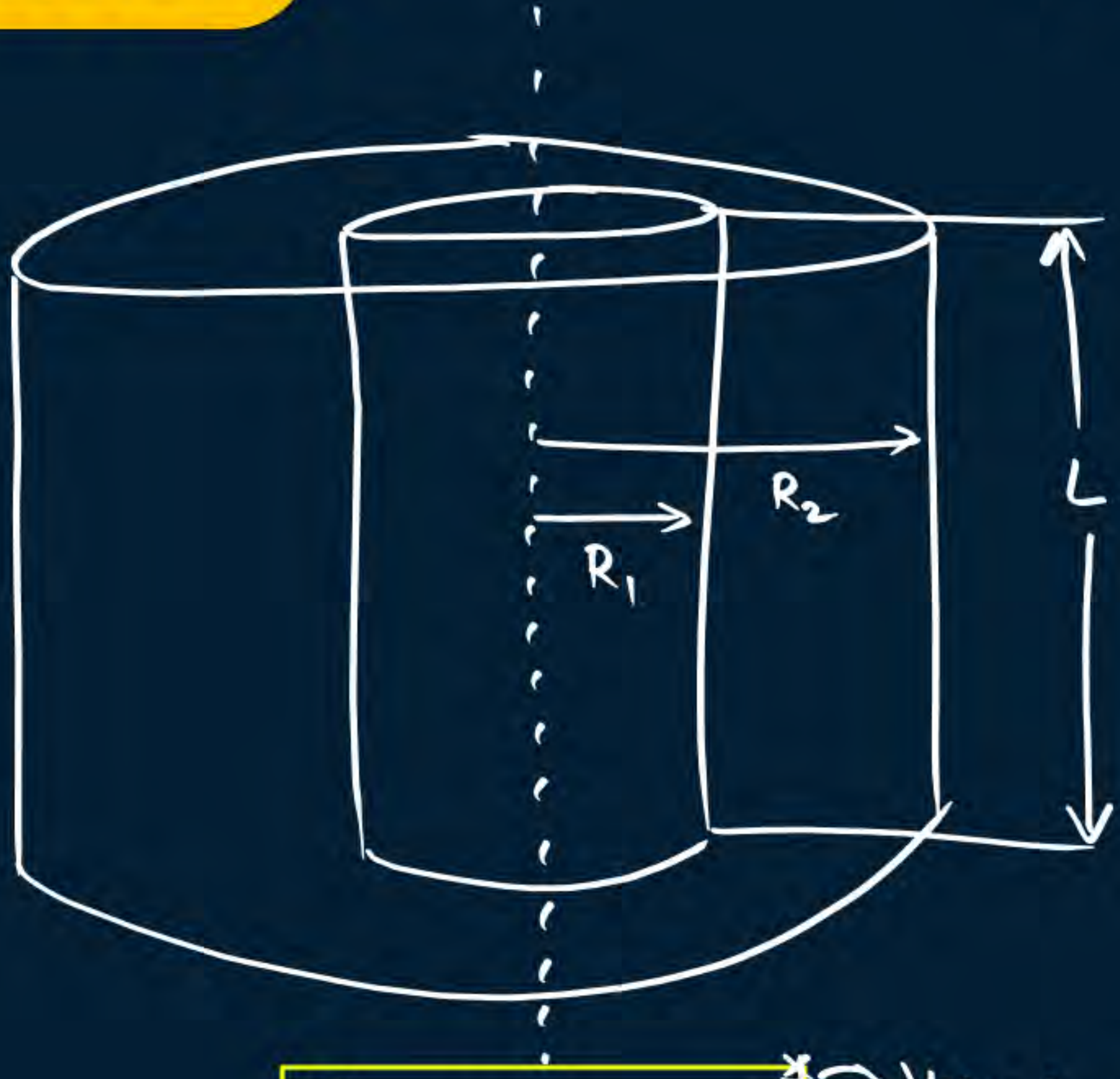
* JEE/NEET

Spherical & Cylindrical Capacitors

$$\boxed{C = 4\pi\epsilon_0 R}$$

Spherical conductor

$$\boxed{C = 4\pi\epsilon_0 \frac{R_1 R_2}{(R_2 - R_1)}}$$

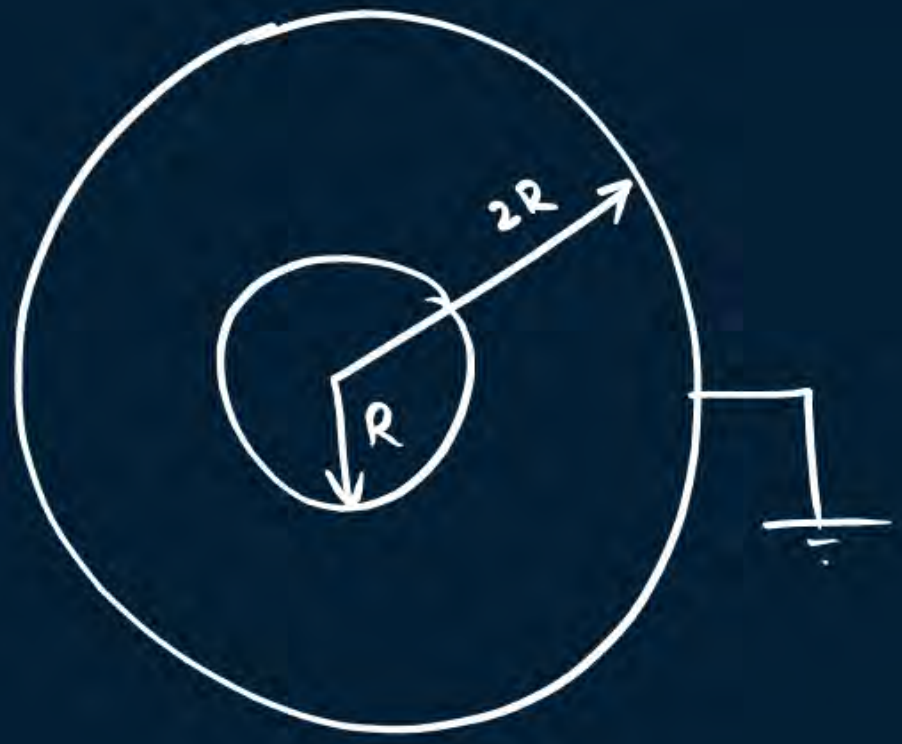


$$\boxed{C = 2\pi\epsilon_0 \frac{L}{\ln\left(\frac{R_2}{R_1}\right)}}$$

* → Very rare

QUESTION

Two concentric conducting spheres of radius R and 2R with outer sphere earthed has capacitance equal to



$$C = 4\pi\epsilon_0 \frac{R_1 R_2}{R_2 - R_1}$$

$$= 4\pi\epsilon_0 \frac{R(2R)}{2R - R}$$

$$= 4\pi\epsilon_0 \frac{\cancel{R}\, 2R}{\cancel{R}}$$

$$= 8\pi\epsilon_0 R \quad \underline{\text{Ans}}$$

Homework

→ Notes
→ DPP
→ Assignment (Tuesday)

Chapterwise
Short Notes
(1-3 Pages)

- Definitions
- imp. concepts
- Formulae

+

Try NCERT Ques (PUNCH)
→ Summary
→ Solutions

Backlog
→ Ch-1
→ ch-2
→ ch-3


PARISHRAM
2026
Lecture - 11
Electrostatic Potential and Capacitance
PHYSICS
Lecture - 11
BY - RAKSHAK SIR
Physics Wallah

Topics *to be covered*

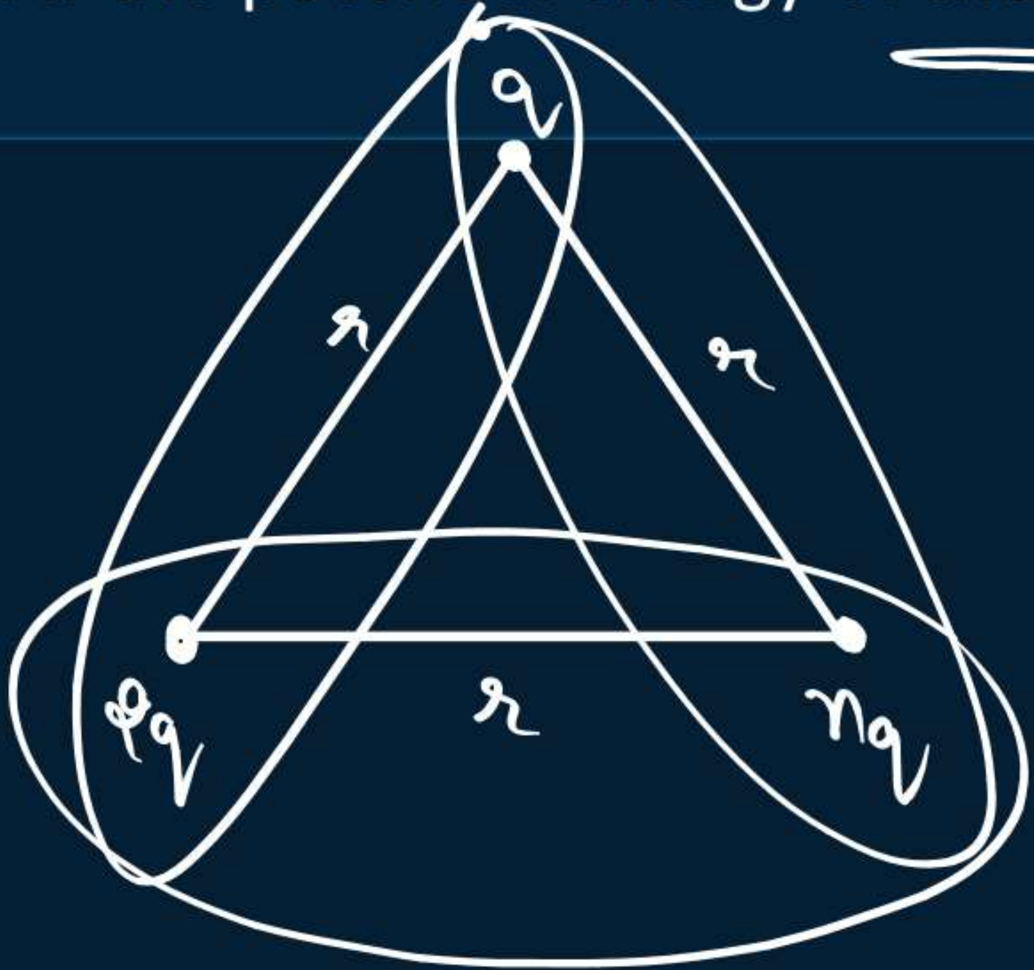
A Practice Session – PYQs, MIQs

QUESTION

(i) Obtain an expression for the electric potential due to a small dipole of dipole moment $\vec{p}$ at a point $\vec{r}$ from its centre, for much larger distances compared to the size of the dipole.

(ii) Three point charges q, $2q$ and nq are placed at the vertices of an equilateral triangle. If the potential energy of the system is zero, find the value of n.

[ALL India CBSE 2023]



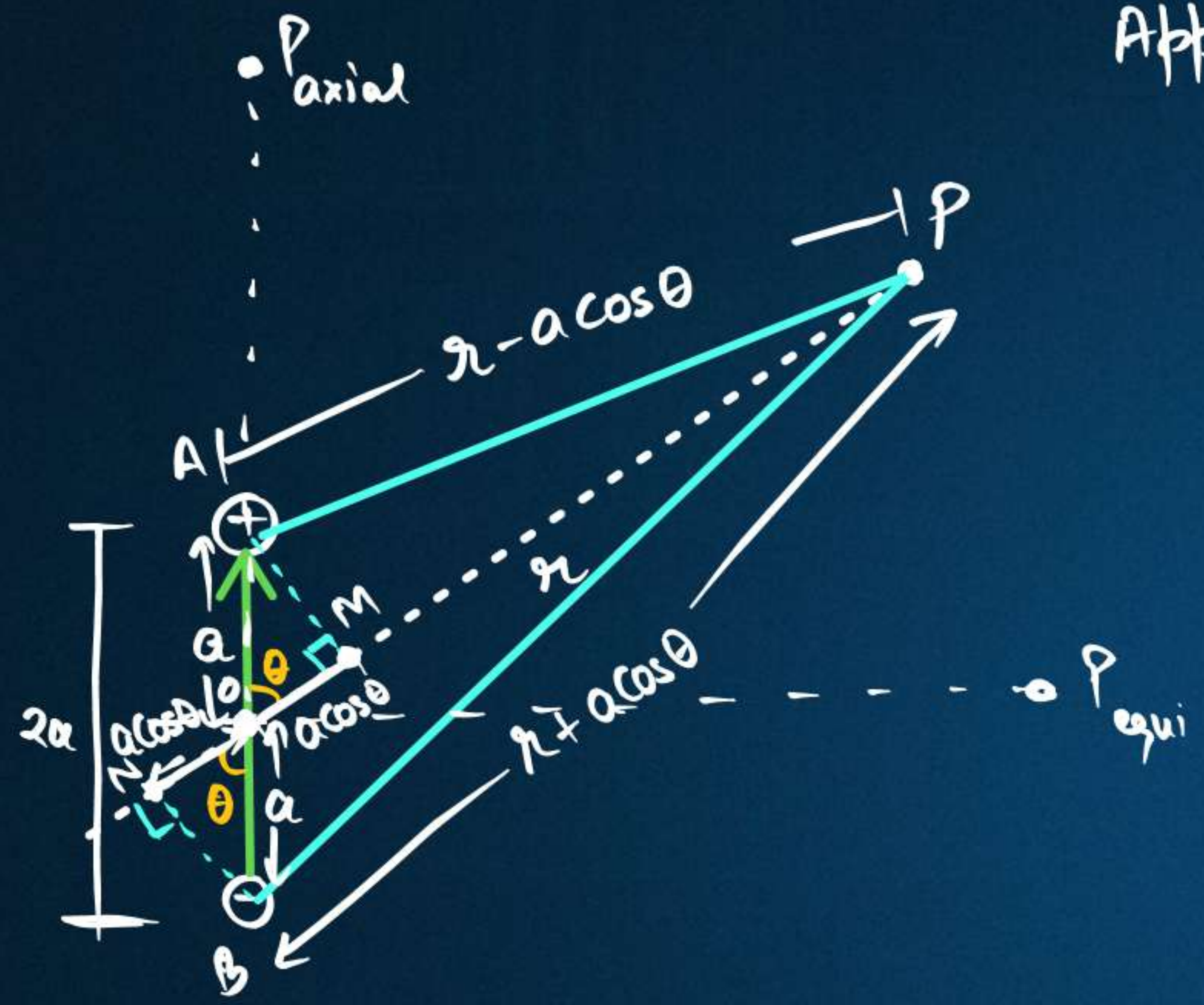
$$V_{net} = \frac{k2q^2}{r} + \frac{knq^2}{r} + \frac{k2nq^2}{r}$$

$$0 = \frac{kq^2}{r}\left[2 + n + 2n\right]$$

$$0 = 2 + 3n$$

$$\boxed{\frac{-2}{3} = n}$$ ✓

Approximately PM = PA and PN = PB



$$V_P = V_+ + V_-$$

$$V_P = \frac{KQ}{r - a\cos\theta} + \left[\frac{-kQ}{r + a\cos\theta}\right]$$

$$= \frac{kQ}{r - a\cos\theta} - \frac{kQ}{r + a\cos\theta}$$

$$= kQ\left[\frac{1}{r - a\cos\theta} - \frac{1}{r + a\cos\theta}\right]$$

$$= kQ\left[\frac{\cancel{r} + a\cos\theta - (\cancel{r} - a\cos\theta)}{r^2 - a^2\cos^2\theta}\right]$$

$$= \frac{k(Q\,2a)\cos\theta}{r^2}$$

$r >> a$

$r^2 - a^2\cos^2\theta \approx r^2$

$$\boxed{V_{net} = \frac{kp\cos\theta}{r^2}}$$

Case 1. $\theta = 0°$

Axial case

$$V_{net} = \frac{kp\cos 0°}{r^2} = \frac{kp}{r^2}$$

Case 2 : $\theta = 90°$

equitorial case

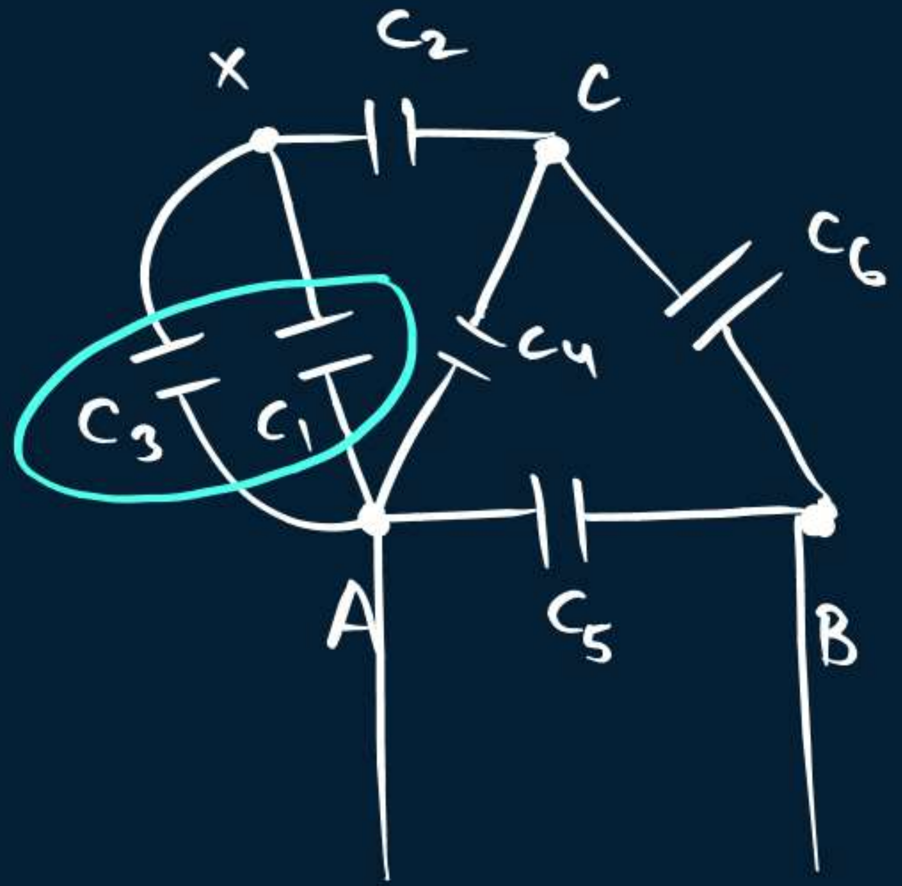
$$V_{net} = \frac{kp\cos 90}{r^2} = 0$$

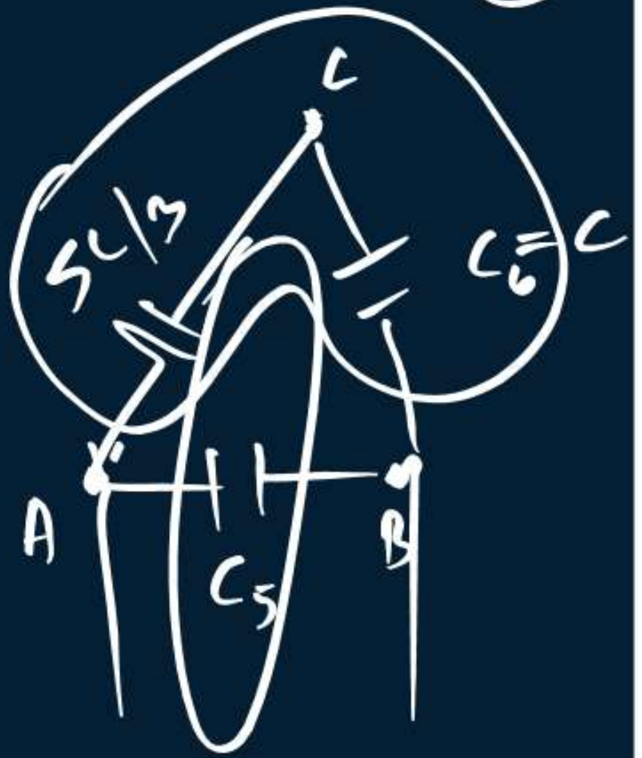
$$\boxed{V_{net} = 0}$$ ✓

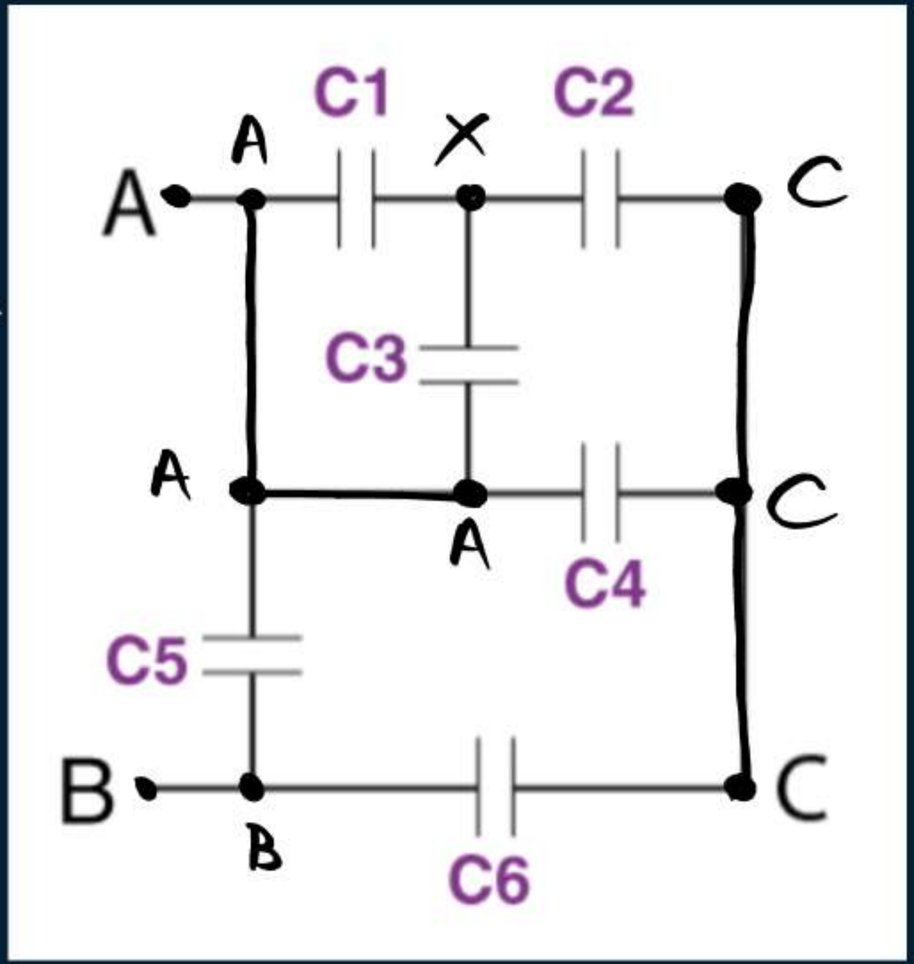
QUESTION

$$\frac{2C\times C}{2C+C} = \frac{2C^{\cancel{2}}}{3\cancel{C}} \qquad C_1 = C_2 = C_3 = C_4 = C_5 = C_6 = C$$

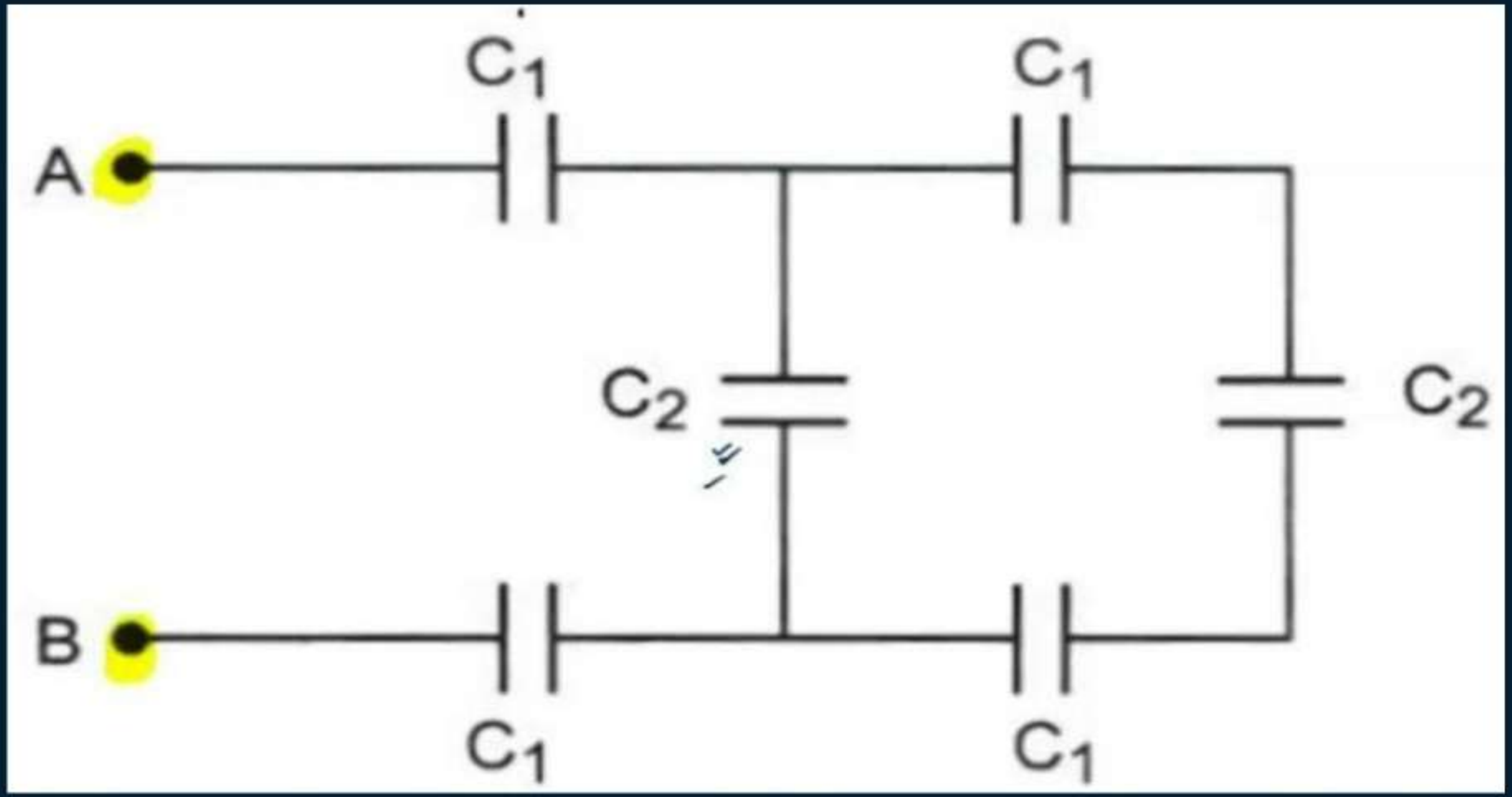
$$\frac{2C}{3}+C = \frac{5C}{3}$$



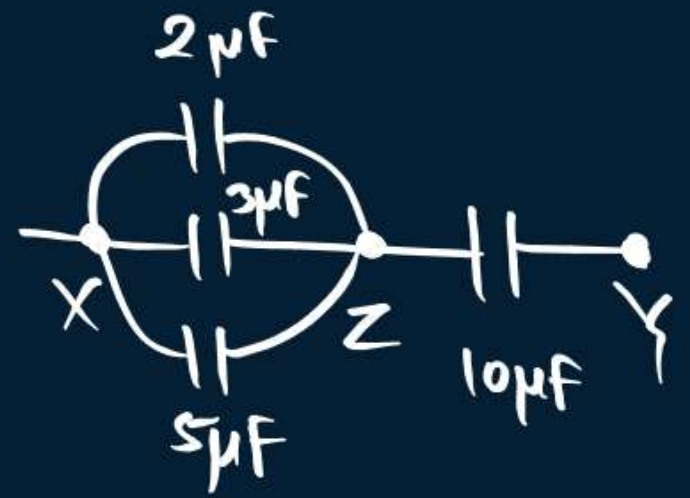


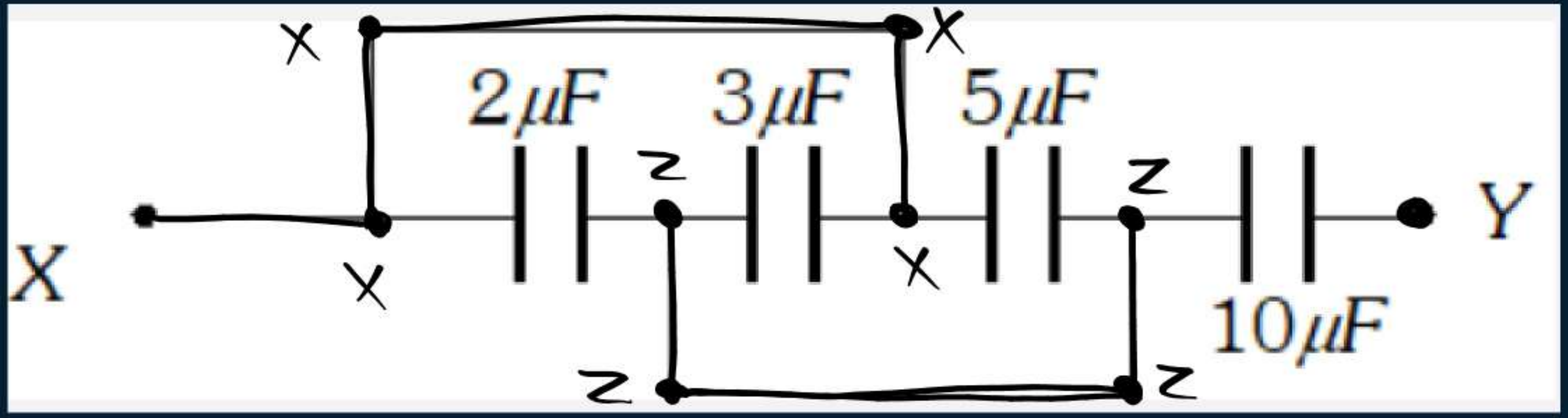


QUESTION



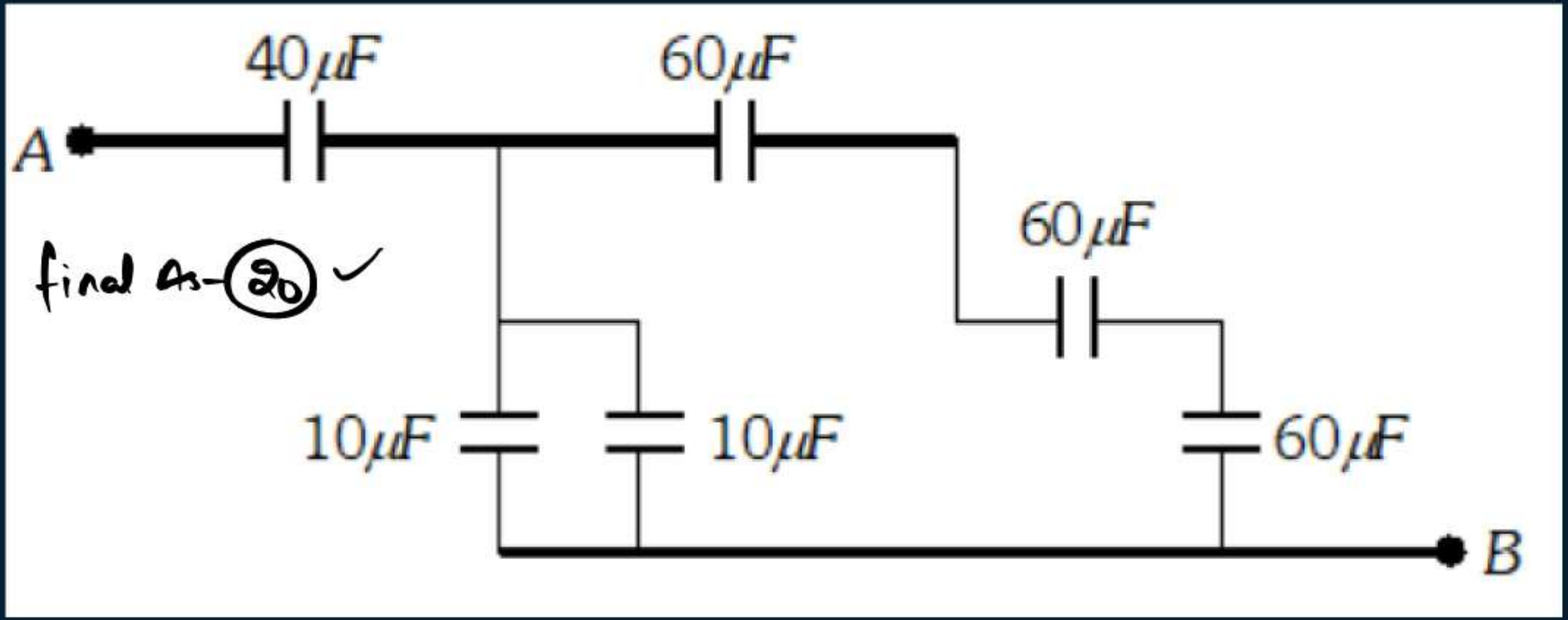
QUESTION



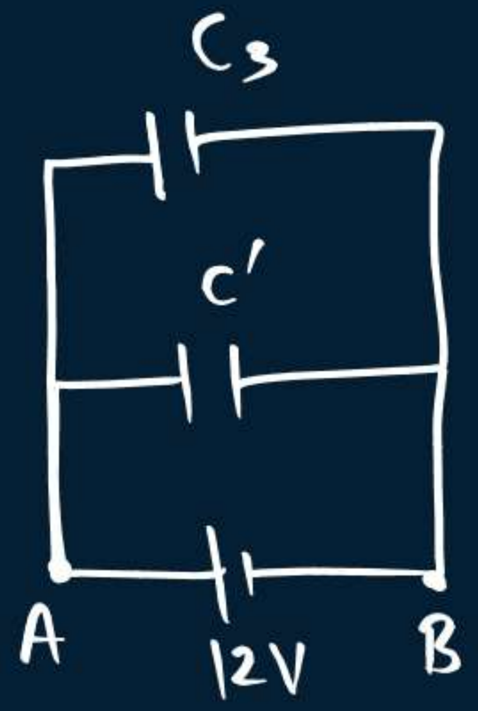


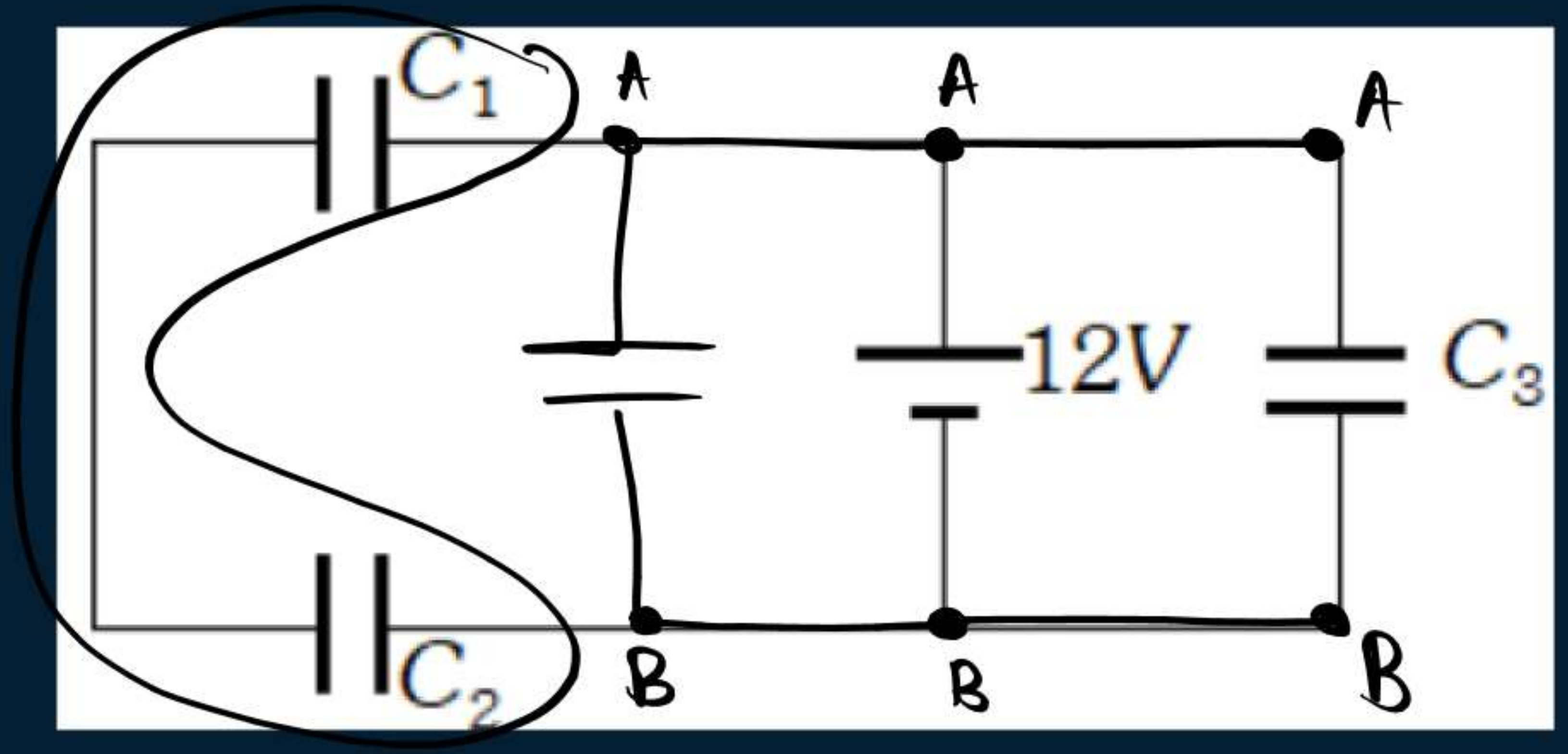
$\equiv$ 5μF Ans

QUESTION

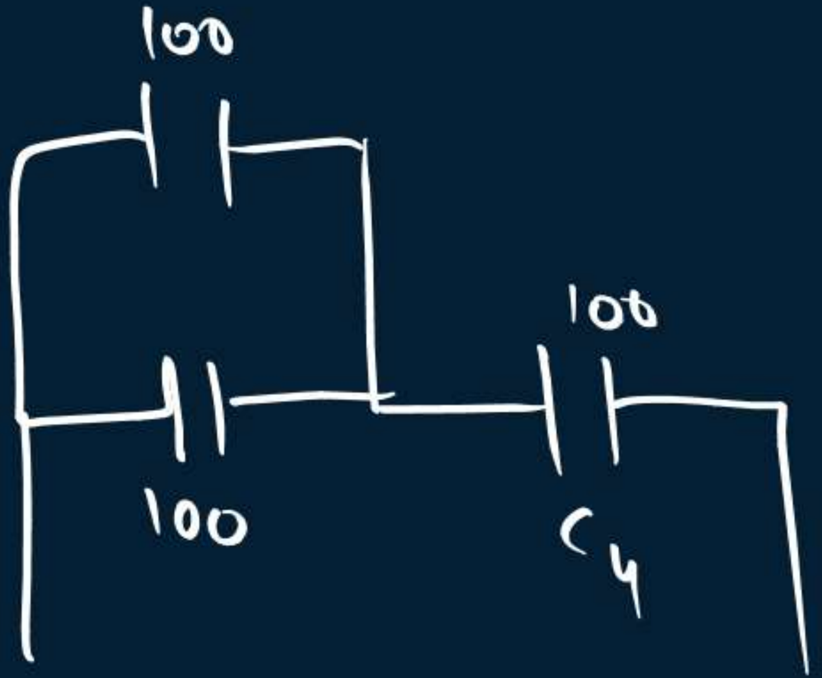


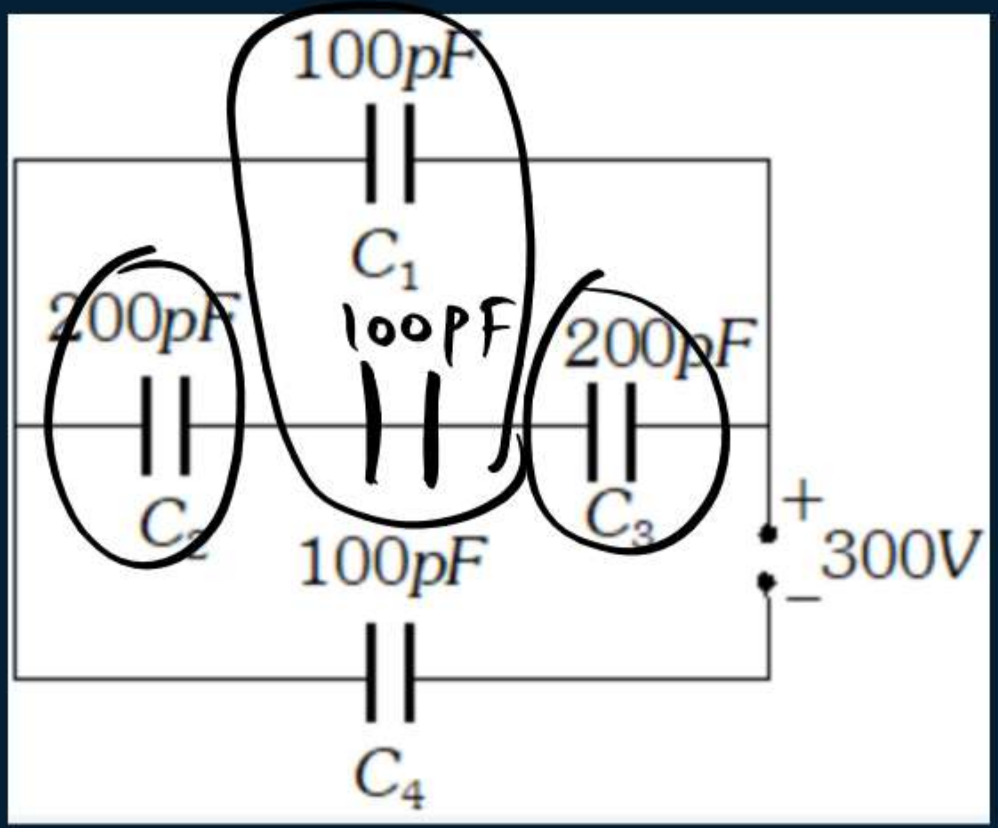
QUESTION





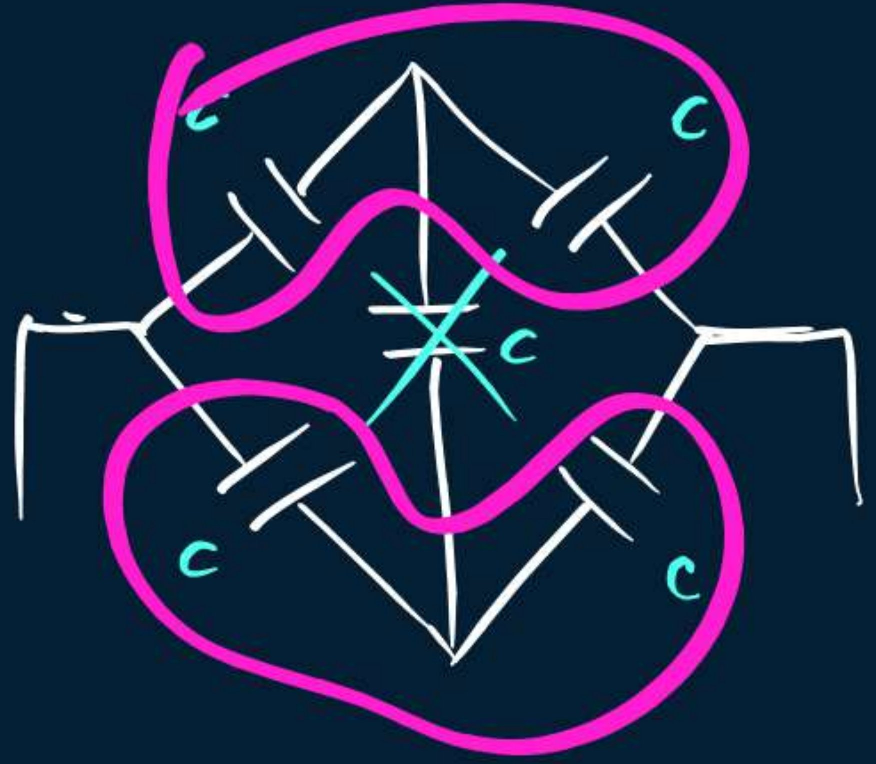
QUESTION





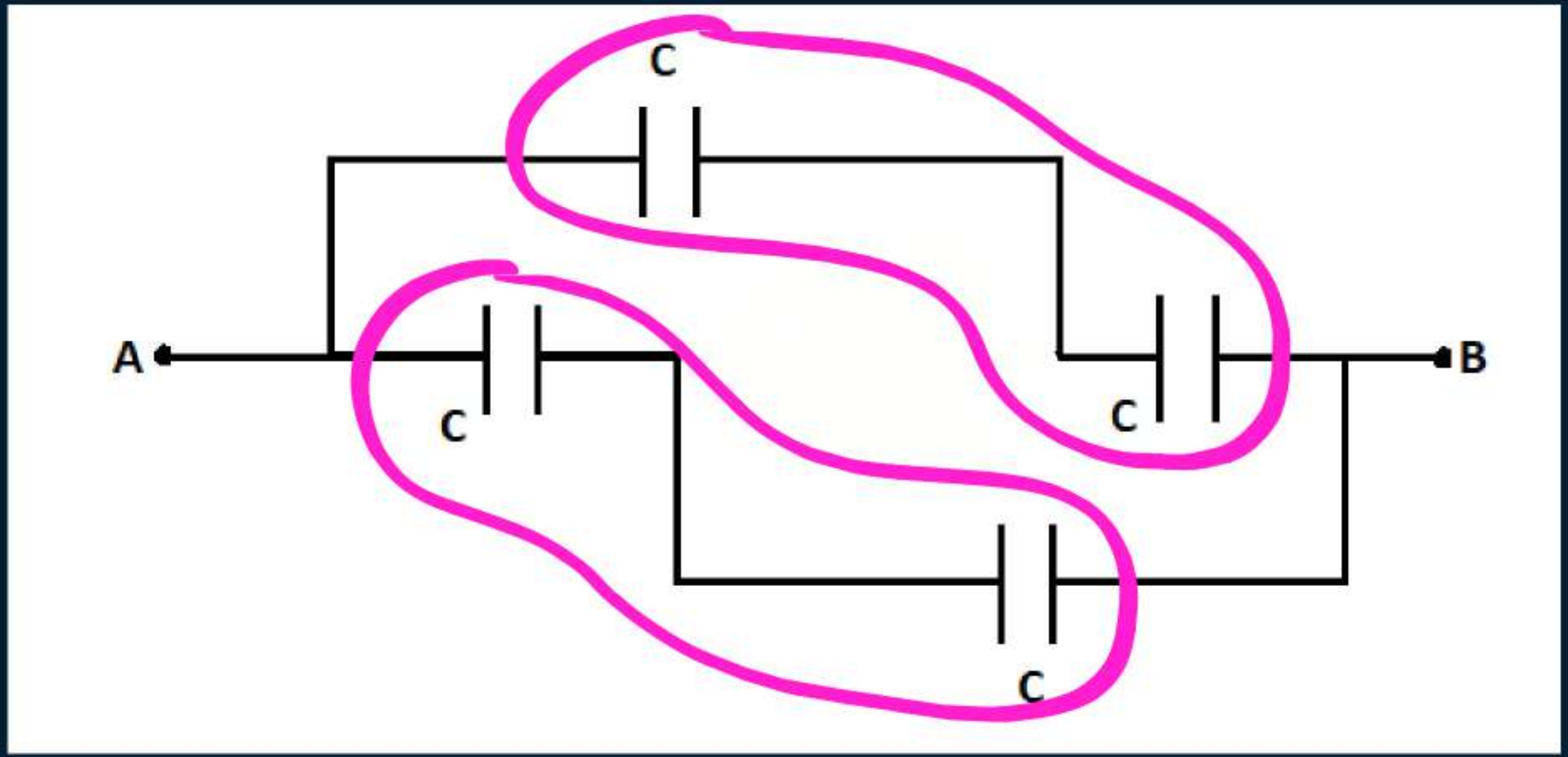
QUESTION

C Ans

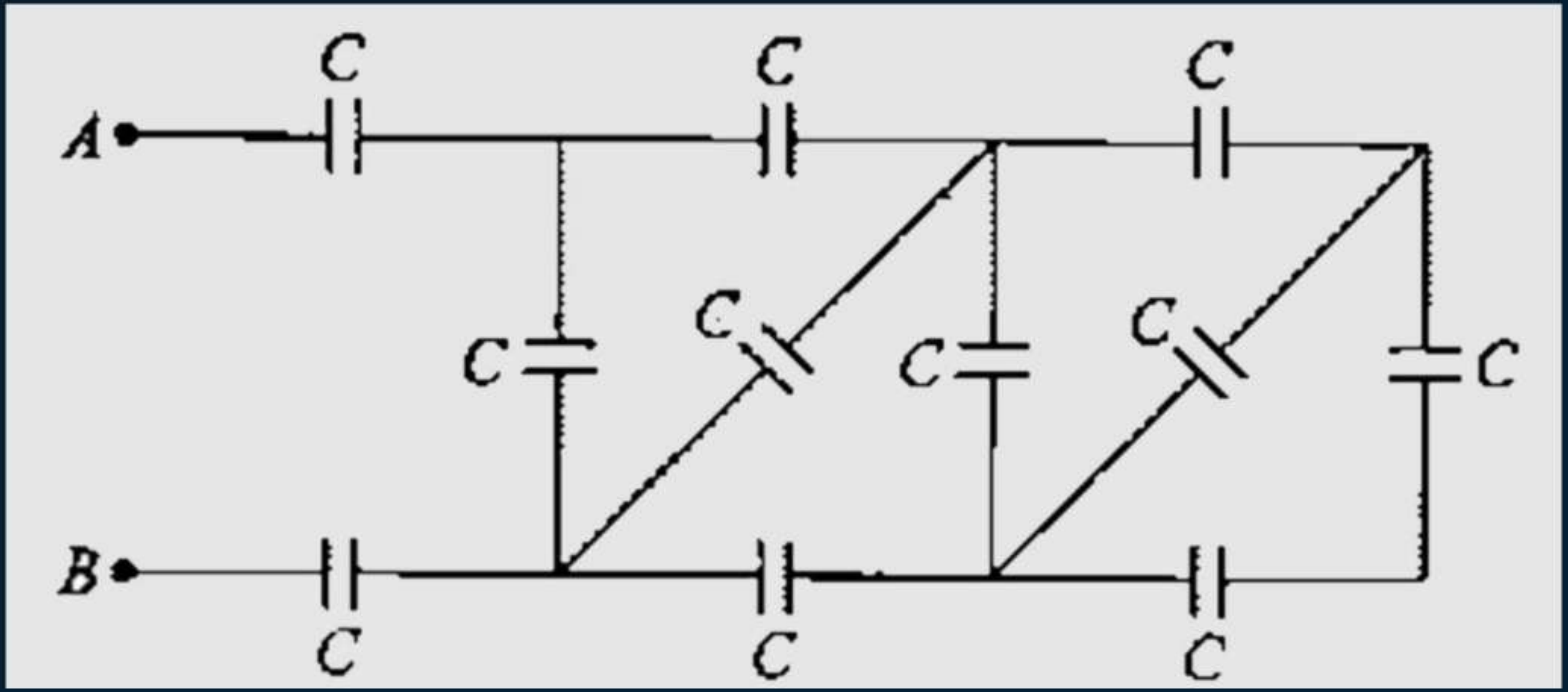


$\frac{c}{c} = \frac{c}{c}$

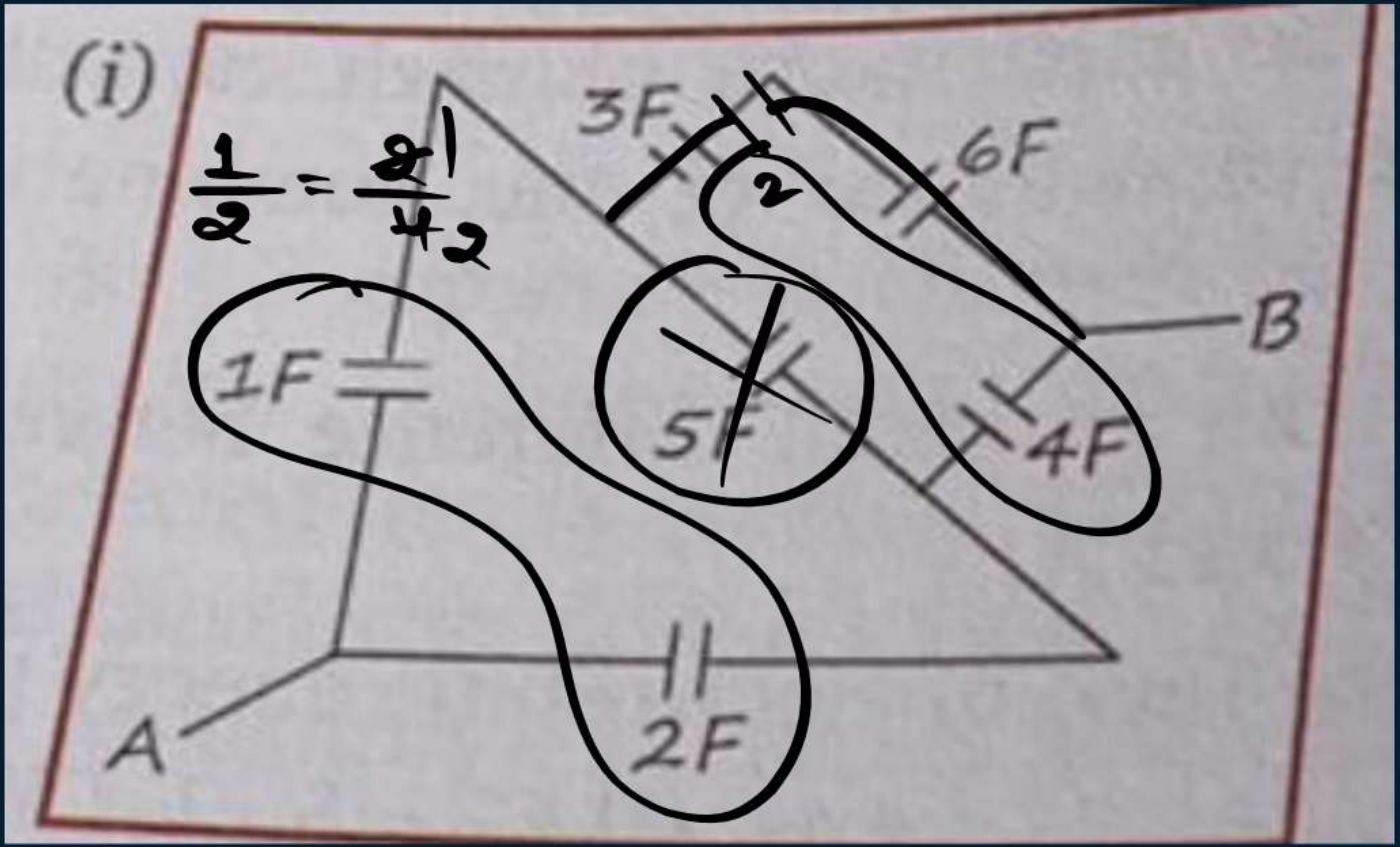
Balanced W.S.B.



QUESTION

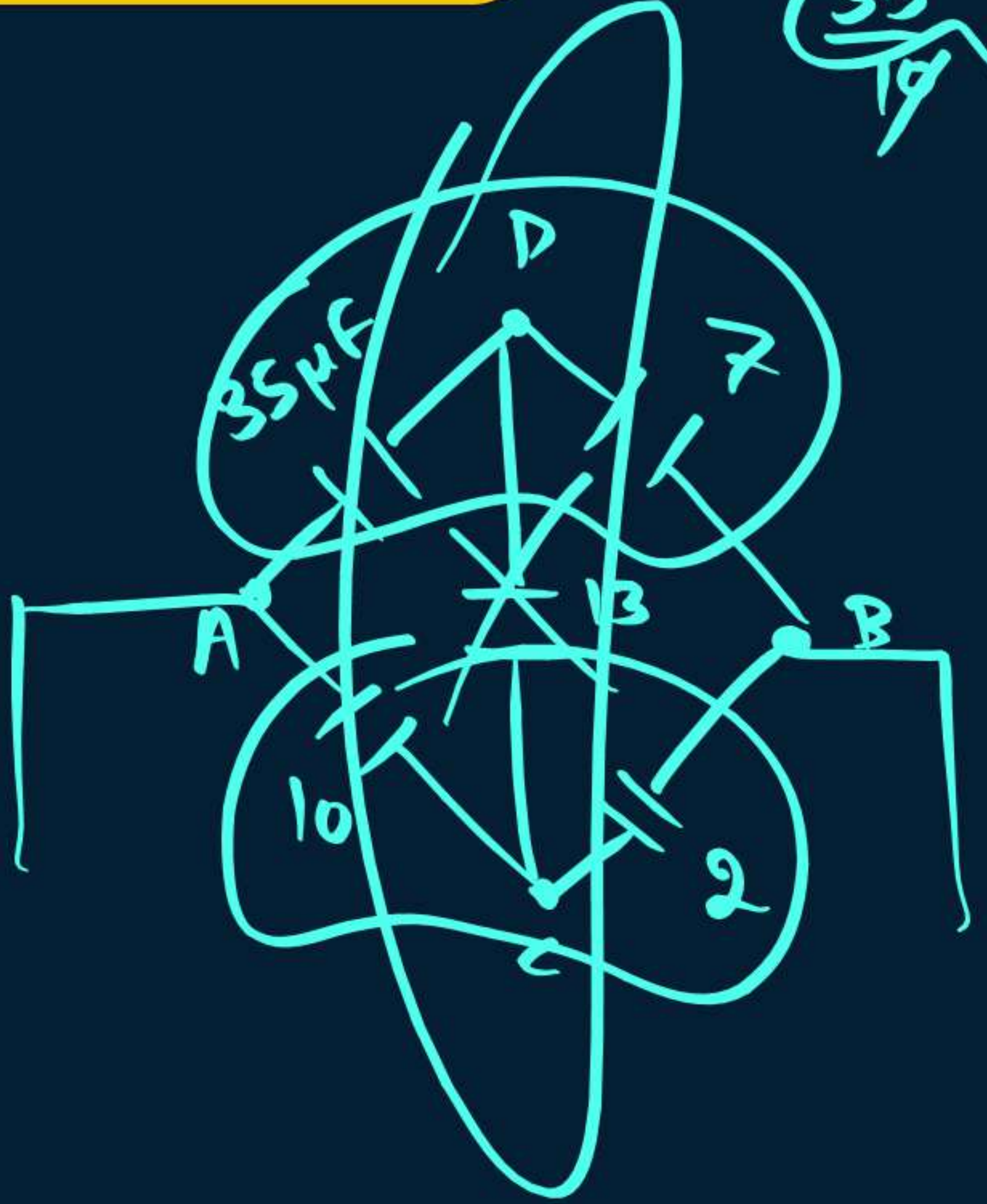


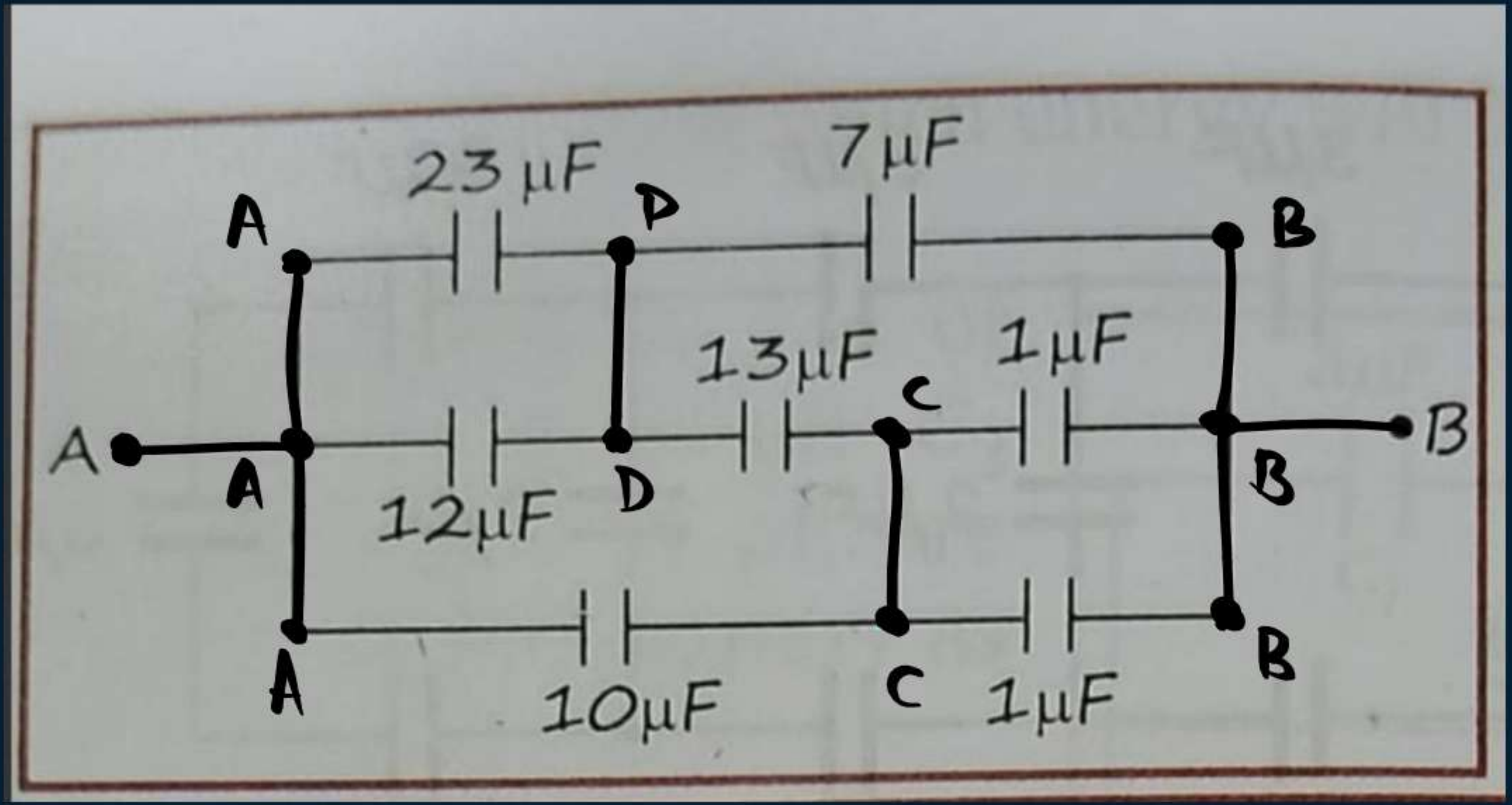
QUESTION



QUESTION

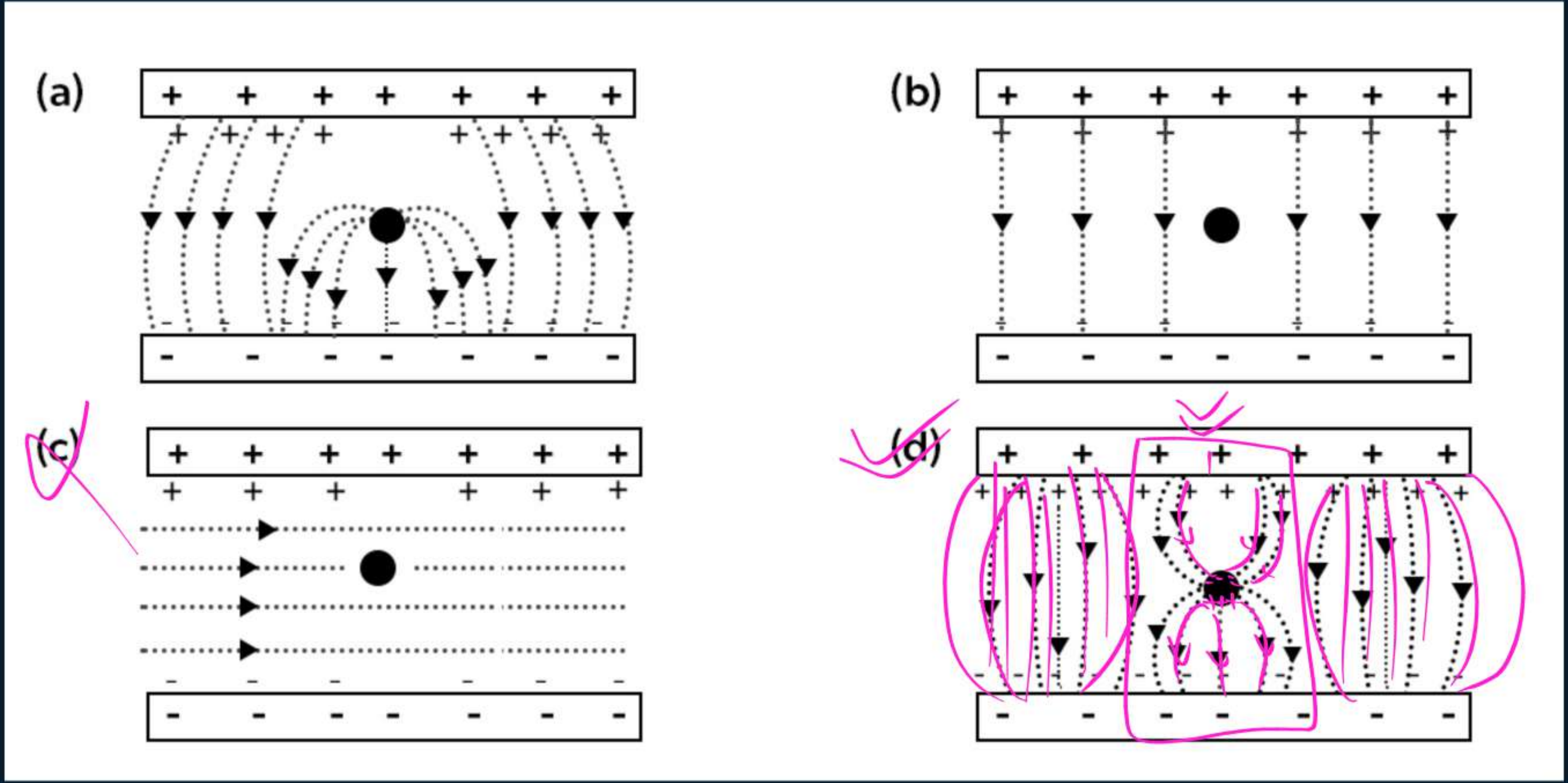
$$\frac{3.5}{14} = \frac{x}{x}\,3.5$$





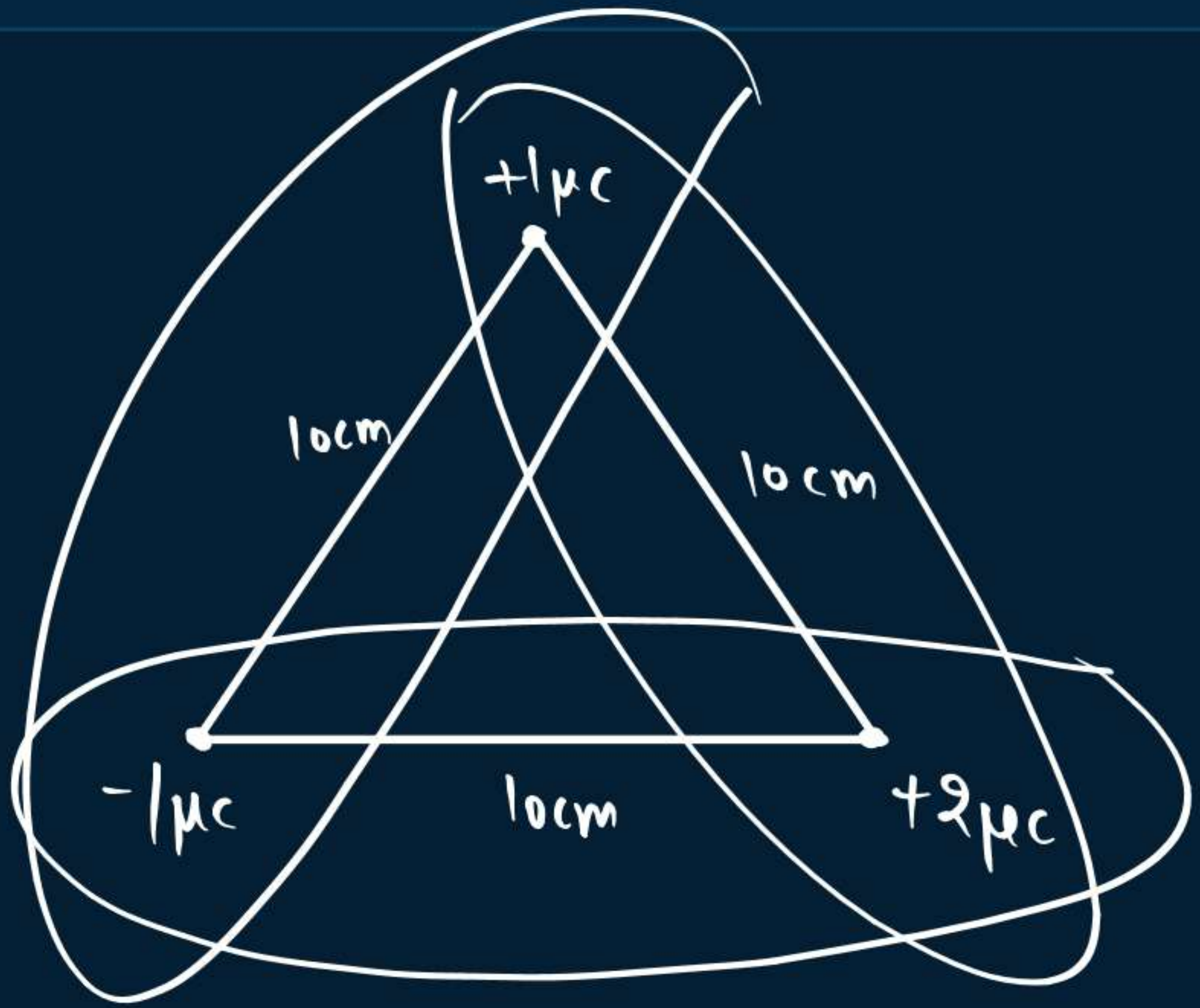
QUESTION

Which of the diagram correctly represents the electric field between two charged plates if a neutral conductor is placed in between the plates? **[2021-22]**



QUESTION

Three point charges $+1\mu C$, $-1\mu C$ and $+2\mu C$ are initially infinite distance apart. Calculate the work done in assembling these charges at the vertices of an equilateral triangle of side 10 cm. [2020]



$$U = \frac{k\,1\times 2}{\frac{10}{100}} - \frac{k\times 1\times 2}{\frac{10}{100}} - \frac{k\,1\,1}{\frac{10}{100}}$$

QUESTION

Notes

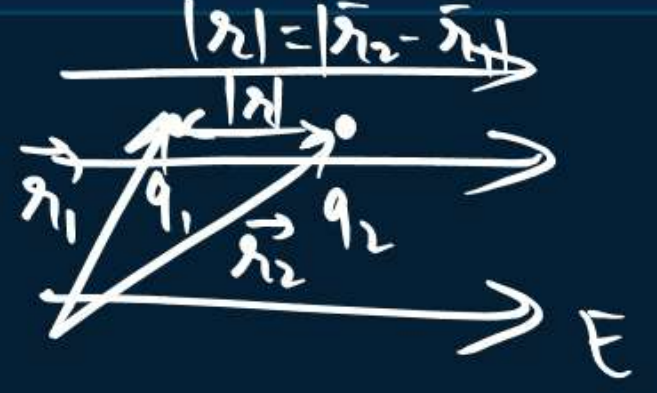
(i) Draw equipotential surfaces for an electric dipole.

(ii) Two point charges $\vec{q}_1$ and $\vec{q}_2$ are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$. Obtain an expression for the potential energy of the system. Notes

(iii) The dipole moment of a molecule is 10^{-30} Cm. It is placed in an electric field $\vec{E}$ of 10^5 V/m such that its axis is along the electric field. The direction $\vec{E}$ is suddenly change by 60° at an instant. Find the change in the potential energy of the dipole, at that instant. **[2024]**

$\boxed{U = -\vec{p}\cdot\vec{E}}$

ii)



$$U_{net} = q_1V_1 + q_2V_2 + \frac{kq_1q_2}{|r_2 - r_1|}$$

iii)

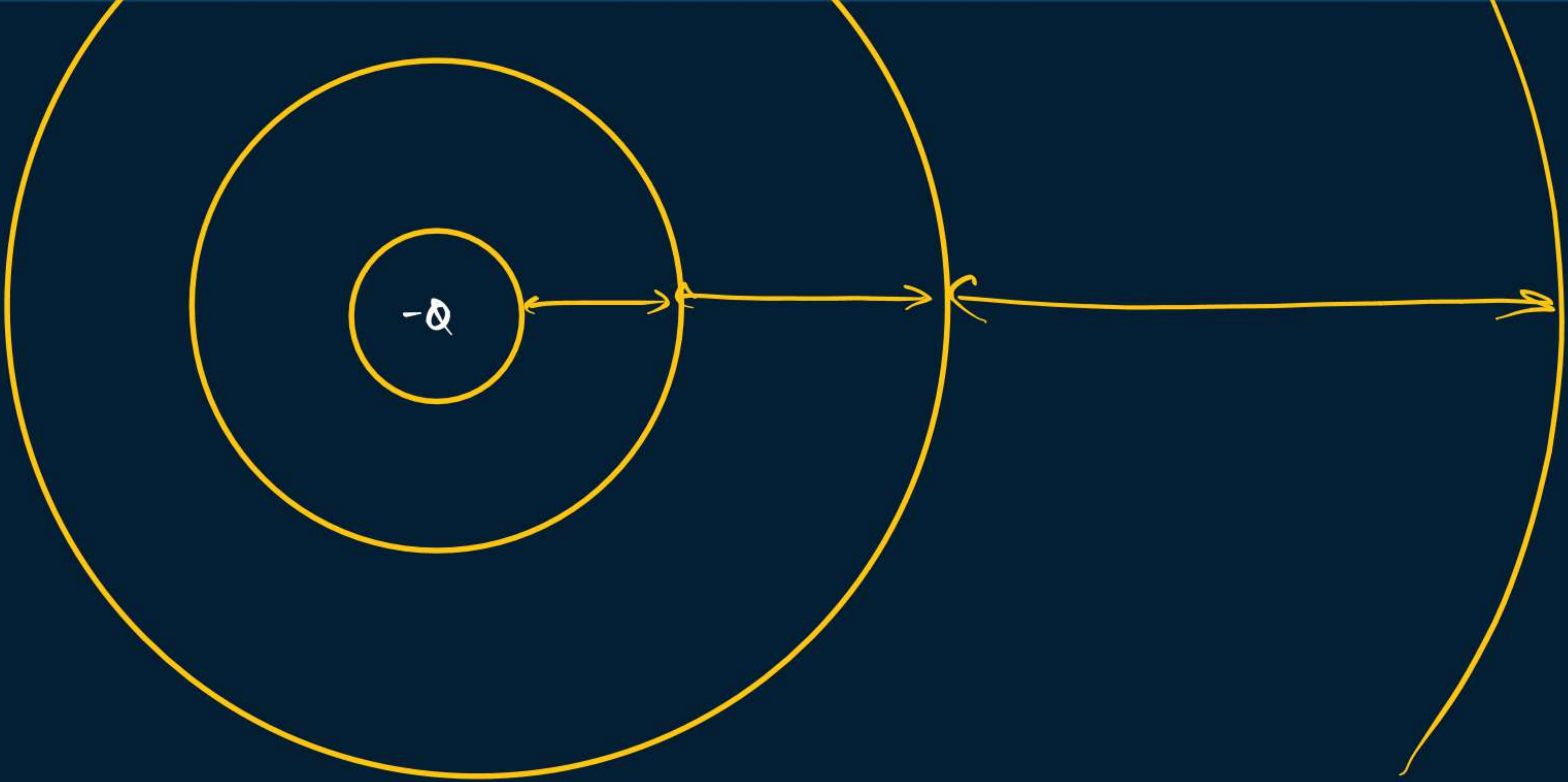
$$U_i = -pE\cos 0^\circ = -pE \quad \ldots (1)$$

$$U_f = -pE\cos 60^\circ = -\frac{pE}{2}$$

$$\Delta U = U_f - U_i$$

QUESTION

Draw equipotential surfaces due to an isolated point charge $(-q)$ and depict the electric field lines. [2020]



QUESTION

The electric potential on the axis of an electric dipole at a distance 'r' from it's centre is V. Then the potential at a point at the same distance on its equatorial line will be

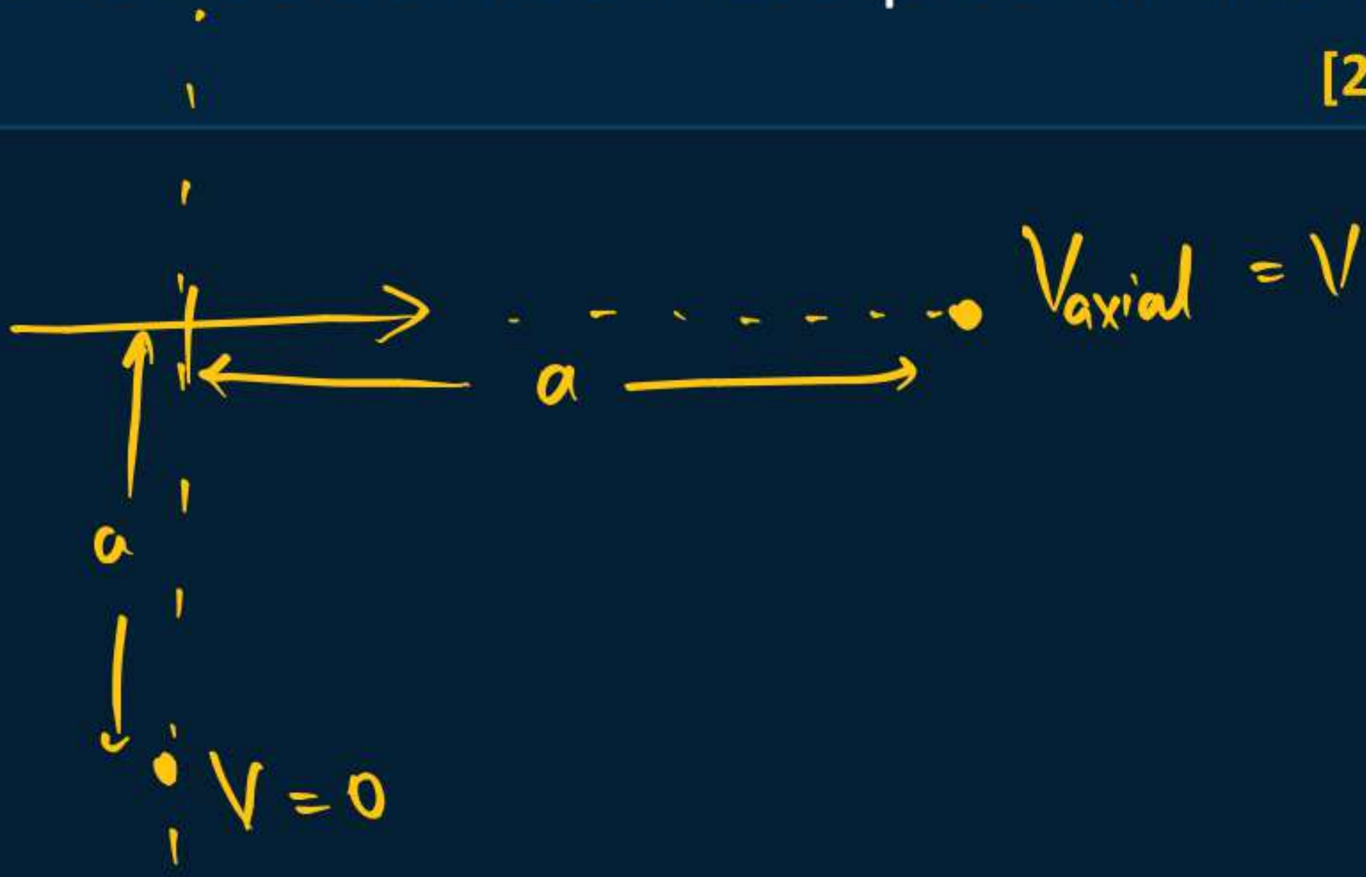
[2022-23]

(A) $2V$

(B) $-V$

(C) $V/2$

(D) Zero



QUESTION

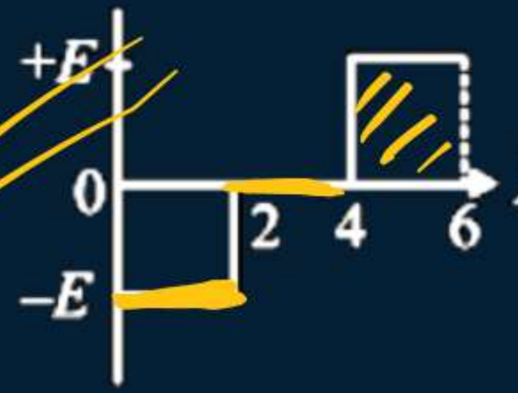
$$\vec{E} = -\frac{dV}{dx}$$

The electric potential V as a function of distance X is shown in the figure.
The graph of the magnitude of electric field intensity E as a function of X is [2022-23]

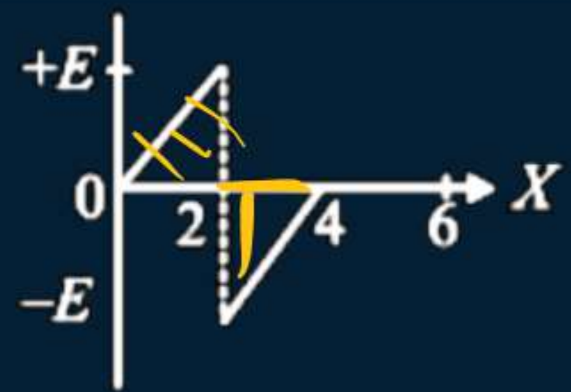
V = Constant $\frac{dV}{dx} = 0$

$E = 0$

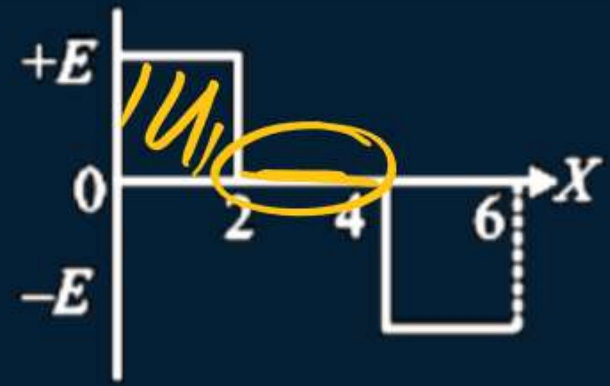
(A)



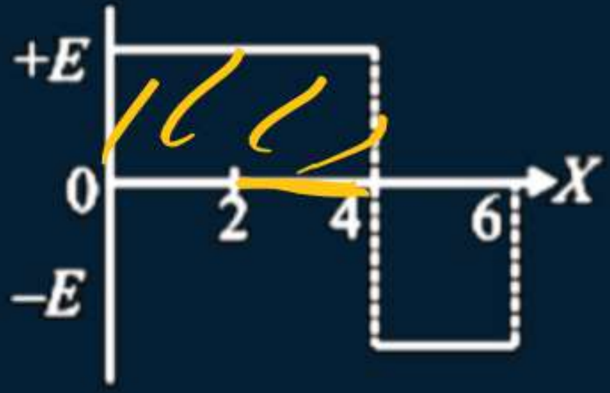
(B)

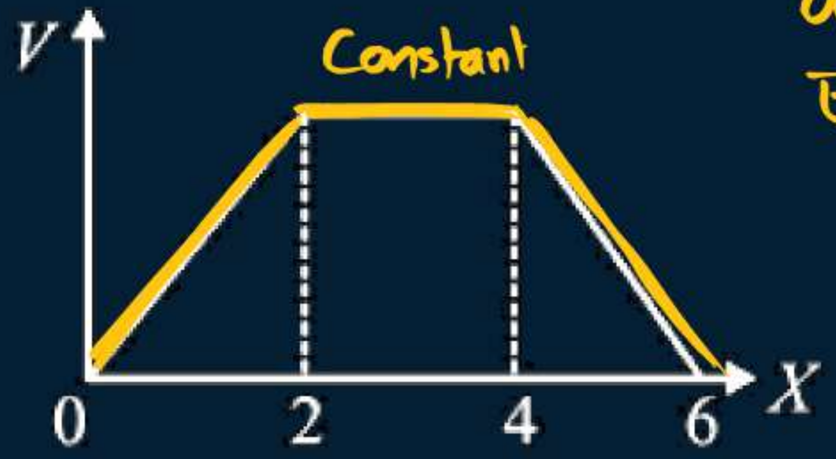


(C)



(D)

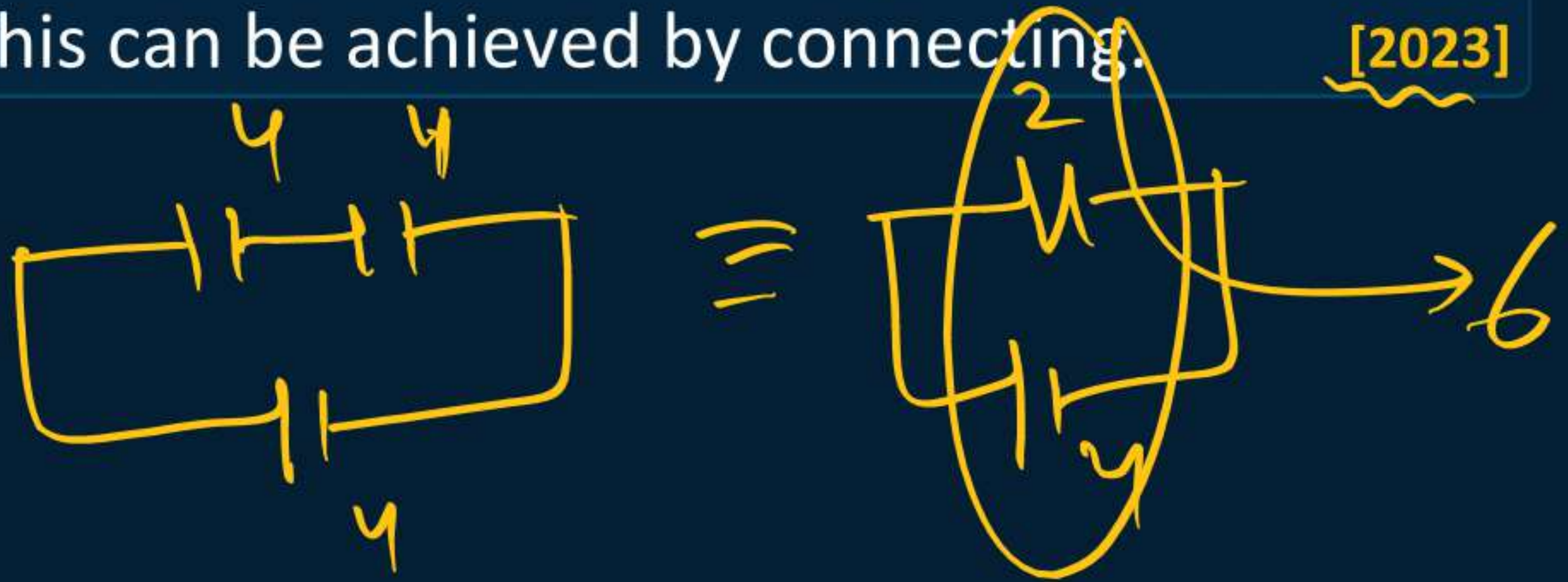




$$\text{slope} = \frac{dy}{dx} = \frac{dV}{dx} = -E$$

QUESTION

Three capacitors, each of 4μF are to be connected in such a way that the effective capacitance of the combination is 6μF. This can be achieved by connecting: [2023]



A All three in parallel

B All three in series

C Two of them connected in series and the combination in parallel to the third.

D Two of them connected in parallel and the combination in series to the third.

QUESTION

$U = qV$

A proton is taken from point P_1 to point P_2, both located in an electric field. The potentials at points P_1 and P_2 are –5V and +5V respectively. Assuming that kinetic energies of the proton at points P_1 and P_2 are zero the work done on the proton is

[2024]

A. ~~zero~~

B. -1.6×10^{-18} J

C. ~~zero~~

D. ~~0.6×10^{-18} J~~

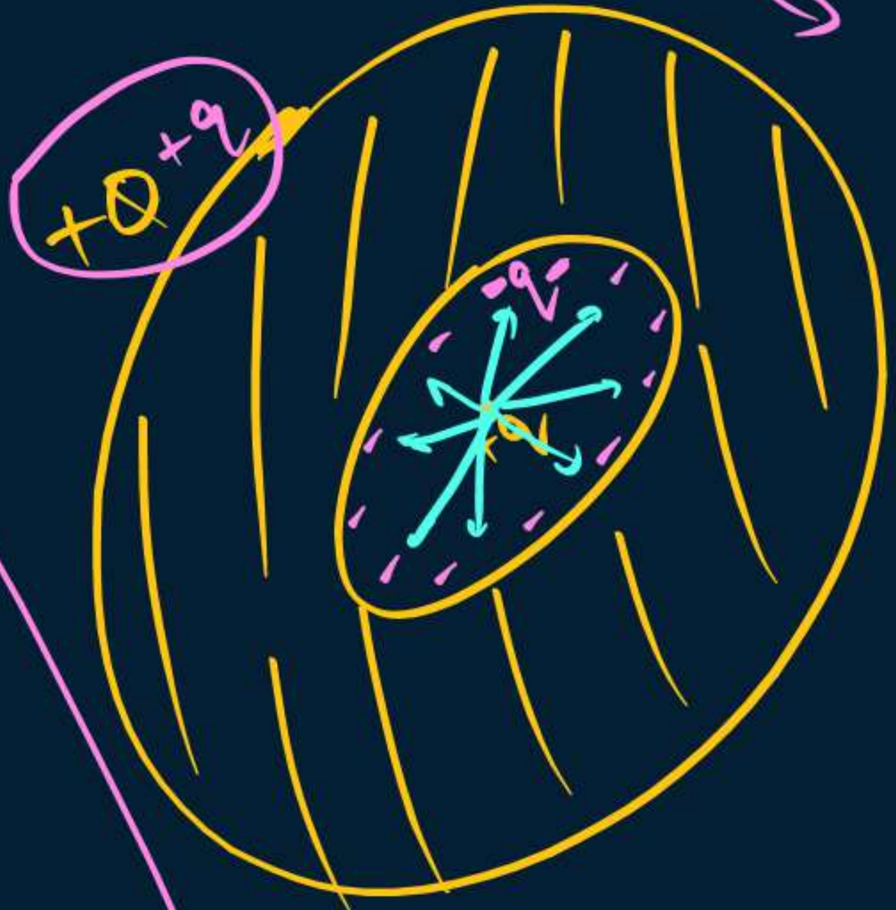
$$W_{ext} = \Delta U$$
$$= U_f - U_i$$
$$= qV_f - qV_i$$
$$= q(V_f - V_i)$$
$$= q(+5-(-5))$$
$$= q \times 10 \longrightarrow 1.6 \times 10^{-19} \times 10 = 1.6 \times 10^{-18} \text{ J} \checkmark$$

QUESTION

An isolated conductor, with a cavity has a net charge $+Q$. A point charge $+q$ is inside the cavity. The charges on the cavity wall and the outer surface are respectively. **[2024]**

$-q$

$+Q+q$



(A) 0 and Q

(B) $-q$ and $Q-q$

(C) $-q$ and $Q+q$

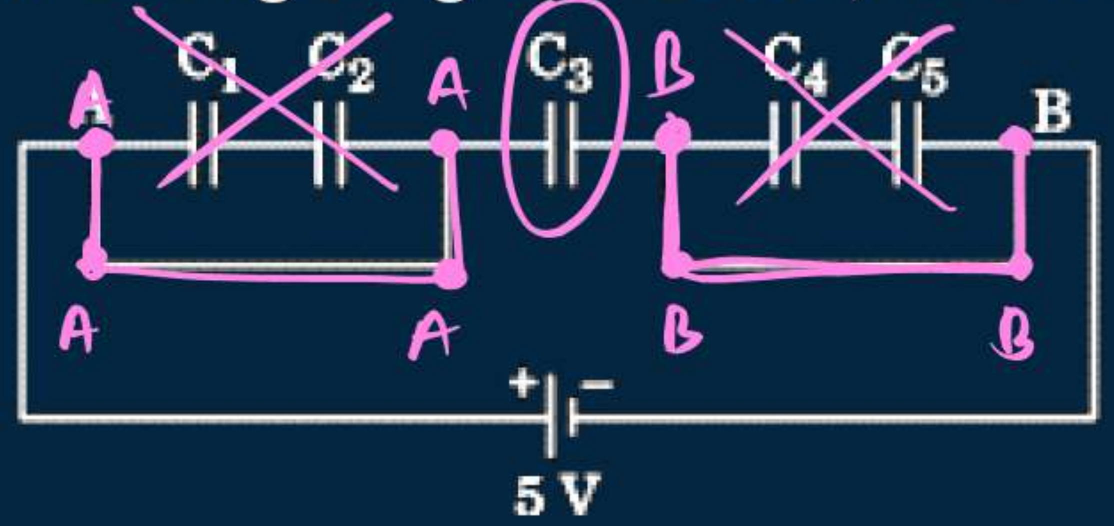
(D) 0 and $Q-q$

RBx

Jitna charge cavity me rakhoge | Utna hi charge surface pe additional aayega

QUESTION

In the figure given below, find the



$\to C_3 = 2\mu F$

(a) equivalent capacitance of the network between point A and B.
Given: $C1 = C_5 = 4\mu F$, $C_2 = C_3 = C_4 = 2\mu F$.

(b) maximum charge supplied by the battery, and

(c) total energy stored ni the network.

[2020]

$Q = CV$
$= 2\mu \times 5 = 10\mu V$

$U = \frac{1}{2} CV^2$

QUESTION

(a) Draw equipotential surface for (i) an electric dipole and (ii) two identical positive charges placed near each other.

(b) In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the separation between the plates is 3 mm.

(i) Calculate the capacitance of the capacitor.

(ii) If the capacitor is connected to 100 V supply, what would be charge on each plate?

$\rightarrow$ Charge $\uparrow$

(iii) How would charge on the plate be affected if a 3 mm thick mica sheet of $k = 6$ is inserted between the plates while the voltage supply remains connected?

[2022-23]

i) $C = \dfrac{\epsilon_0 A}{d}$

$= \dfrac{8.85 \times 10^{-12} \times 6 \times 10^{-3}}{3 \times 10^{-3}}$

ii) $Q = CV$

$= C \times 100$

iii) $Q_i = C \times 100$

$C' = KC$

$Q_f = KCV$

$Q_f = 6C \times 100$

$= Q_f - Q_i = 6CV - CV$

$= CV(6-1)$

$= 5CV$

$= 5 \times 100 \times C$

QUESTION

Notes

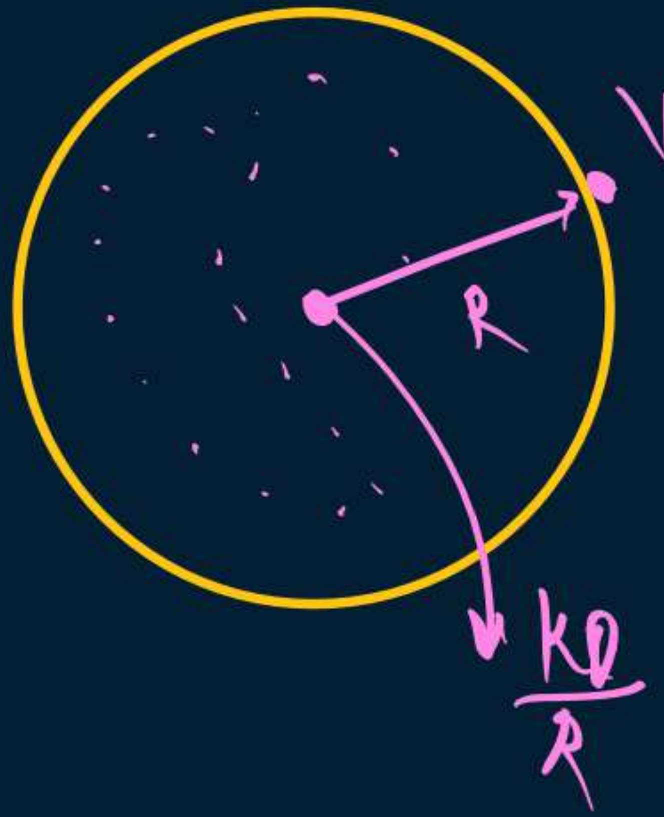
Write two important characteristics of equipotential surfaces. [2020]

QUESTION

Notes

(i) Obtain the expression for the capacitance of a parallel plate capacitor with a dielectric medium between its plates.

(ii) A charge of 6μC is given to a hollow metallic sphere of radius 0.2 m. Find the potential at (i) the surface and (ii) the centre of the sphere. **[2024]**



$$V = \frac{KQ}{R} = \frac{9\times10^{9} \times 6\times10^{-6}}{0.2}$$

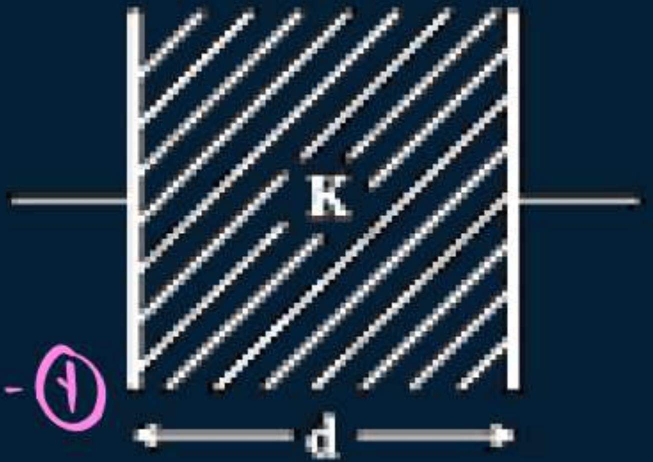
QUESTION

The space between the plates of a parallel plate capacitor is completely filled in two ways. In the first case, it is filled with a slab of dielectric constant K. In the second case it is filled with two slabs of equal thickness and dielectric constants K_1 and K_2 respectively as shown in the figure. The capacitance of the capacitor is same in the two cases obtain the relationship between K, K_1 and K_2 **[AI 2020]**

$$\frac{C}{C_1} = \frac{\frac{\epsilon_0 A}{d} K}{\frac{\epsilon_0 A}{d} \frac{2K_1K_2}{K_1+K_2}}$$

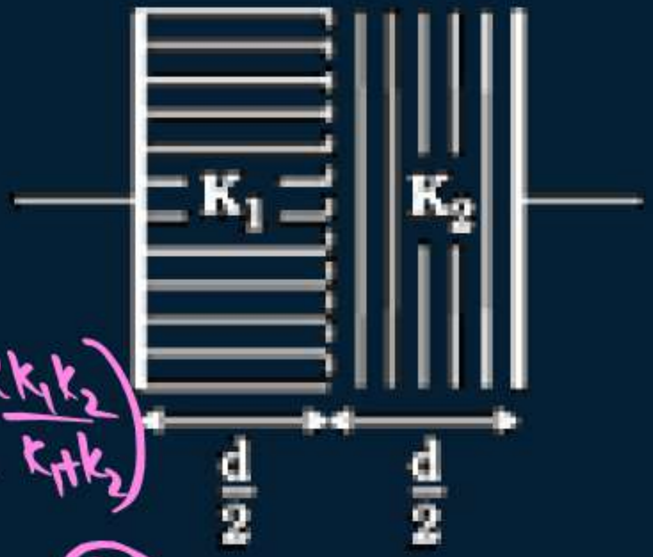
$$\boxed{\frac{2K_1K_2}{K_1+K_2} = K}$$

$$C = \frac{K\epsilon_0 A}{d} \quad \text{...(1)}$$



(Case 1)

$$C = \frac{\epsilon_0 A}{d}\left(\frac{2K_1K_2}{K_1+K_2}\right) \quad \text{...(2)}$$



(Case 2)

QUESTION

Notes

Two small conducting balls A and B of radius r_1 and r_2 have charges q_1 and q_2 respectively. They are connected by a wire. Obtain the expression for charges on A and B, in equilibrium. **[2023]**

$$Q_1' = \frac{Q_{net}\, r_1}{r_1 + r_2}$$

QUESTION

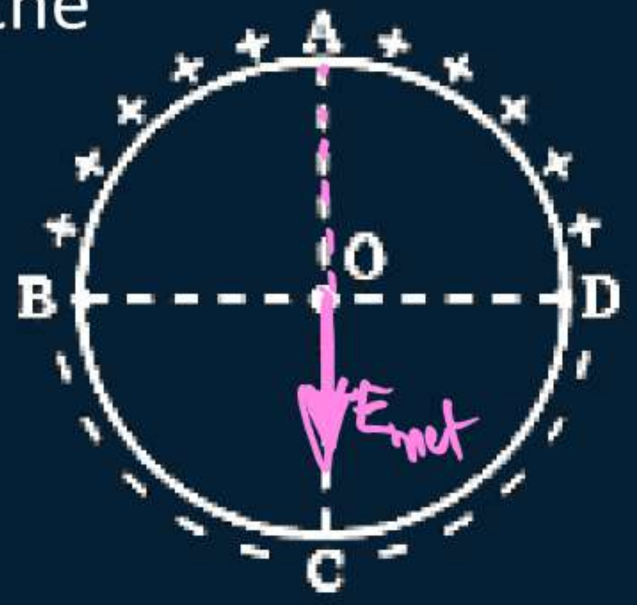
$V = 0$

Assertion (A): Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC. T

Reason (R): It is so because the net potential at O is not zero. F **[2023]**

A If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

B Ifboth Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).



C If Assertion (A) is true but Reason (R) is false.

D If both Assertion (A) and Reason (R) are false.

QUESTION

N small conducting liquid droplets, each of radius *r*, are charged to a potential V each. These droplets coalesce to from a single large drop without any charge leakage. Find the potential of the large drop. **[2020]**

N- drops

$$\boxed{R = n^{1/3} r}$$

$$V = \frac{kq}{r}$$

$$C = 4\pi\epsilon_0 r$$

$$V' = \frac{kNq}{R}$$

$$V' = \frac{kNq}{N^{1/3} r} = N^{2/3} V$$

$$\boxed{V' = N^{2/3} V}$$

$$C' = 4\pi\epsilon_0 R$$

$$C' = 4\pi\epsilon_0 n^{1/3} r$$

$$\boxed{C' = n^{1/3} C}$$

QUESTION

Three point charges Q, q and $-q$ are kept at the vertices of an equilateral triangle of side L as shown in figure. What is

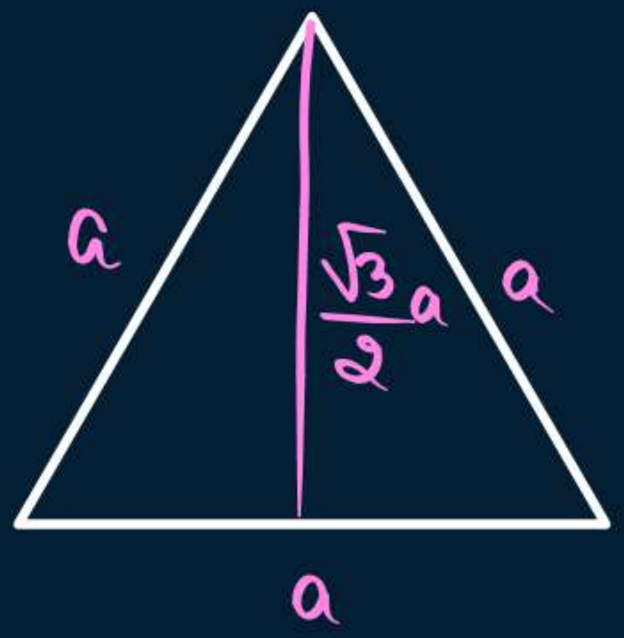
(i) the electrostatic potential energy of the arrangement? and

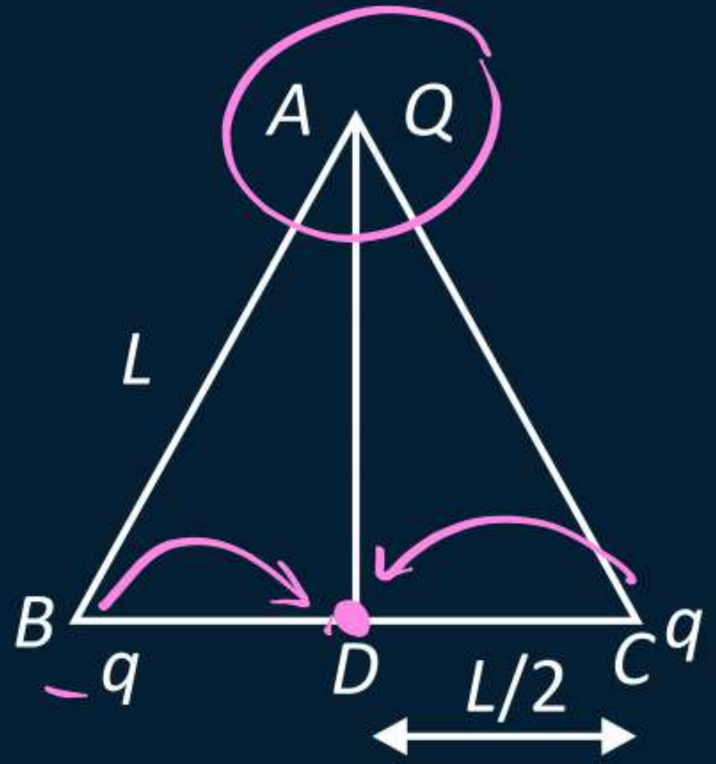
(ii) the potential at point D? **[2023]**

i) $U_{net} = \frac{kQ-q}{L} + \frac{kQq}{L} - \frac{kq^2}{L}$

ii) $V_D = V_{+q} + V_{-q} + V_{+Q}$

$= \cancel{\frac{kq}{L/2}} - \cancel{\frac{kq}{L/2}} + \left(\frac{kQ}{\frac{\sqrt{3}}{2}L}\right)$ Ans





Homework

All Ques

Practice Again !!!