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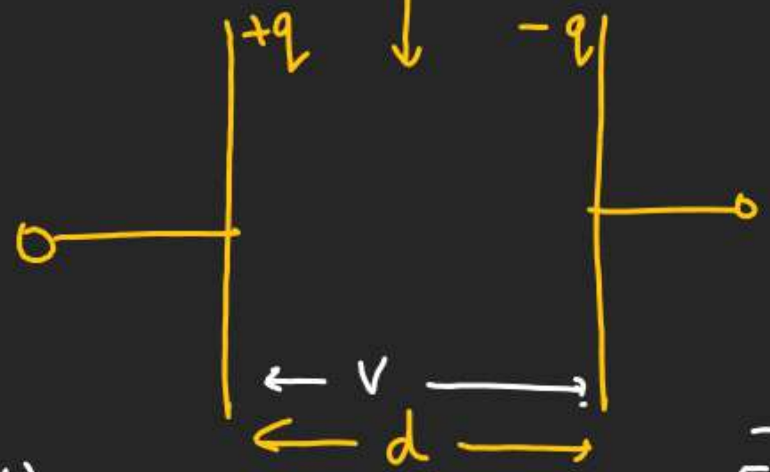
Capacitor

(*)

$$\left[C = \frac{\varepsilon_0 A}{d}\right]$$



(*)

$$\boxed{q = CV}$$

Combination of parallel plate Capacitor

Series Combination

↳ Charges in Series Combination is same in all the Capacitor

Parallel Combination

↳ In parallel Combination Potential difference in each Capacitor is Same

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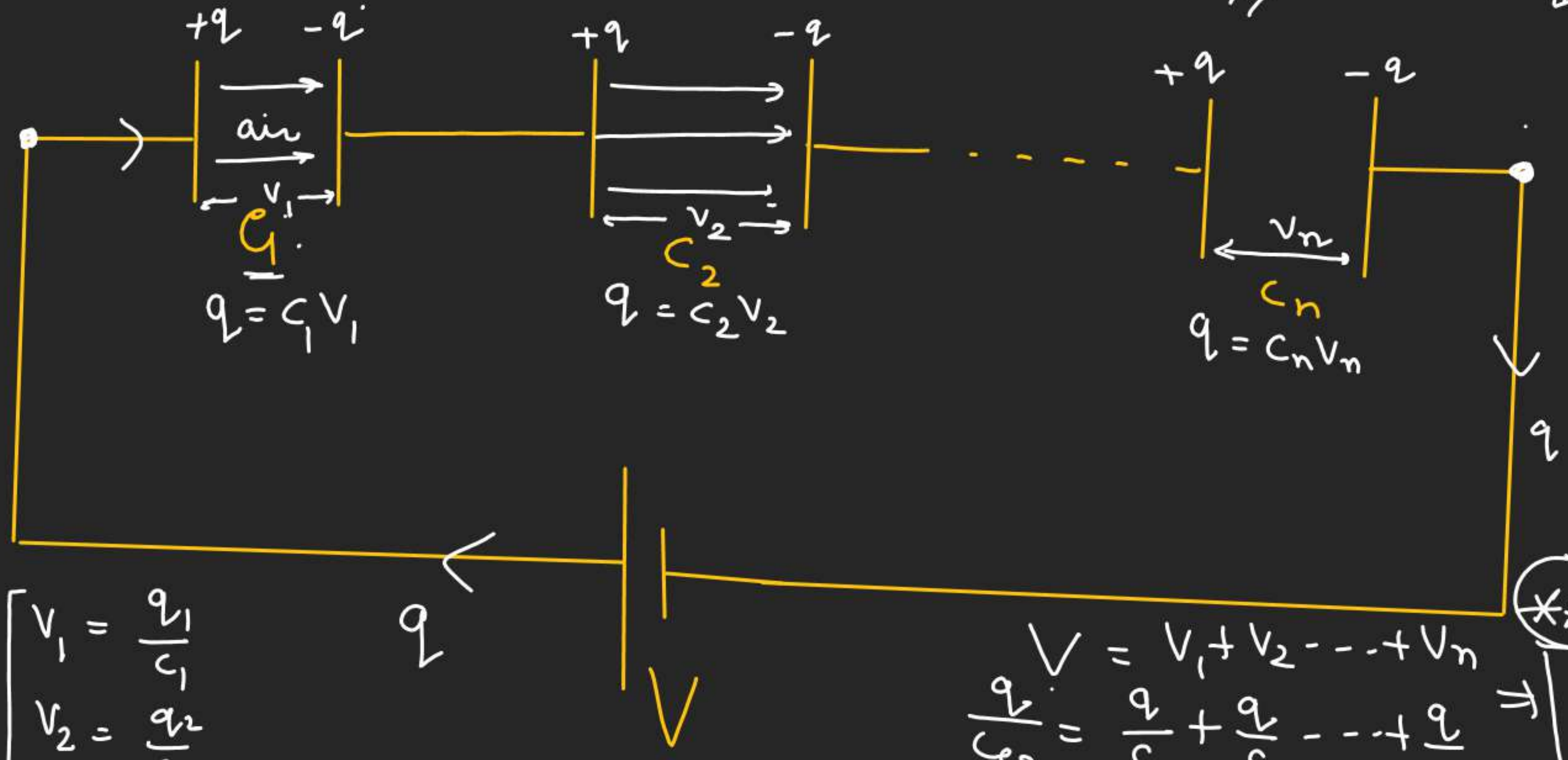
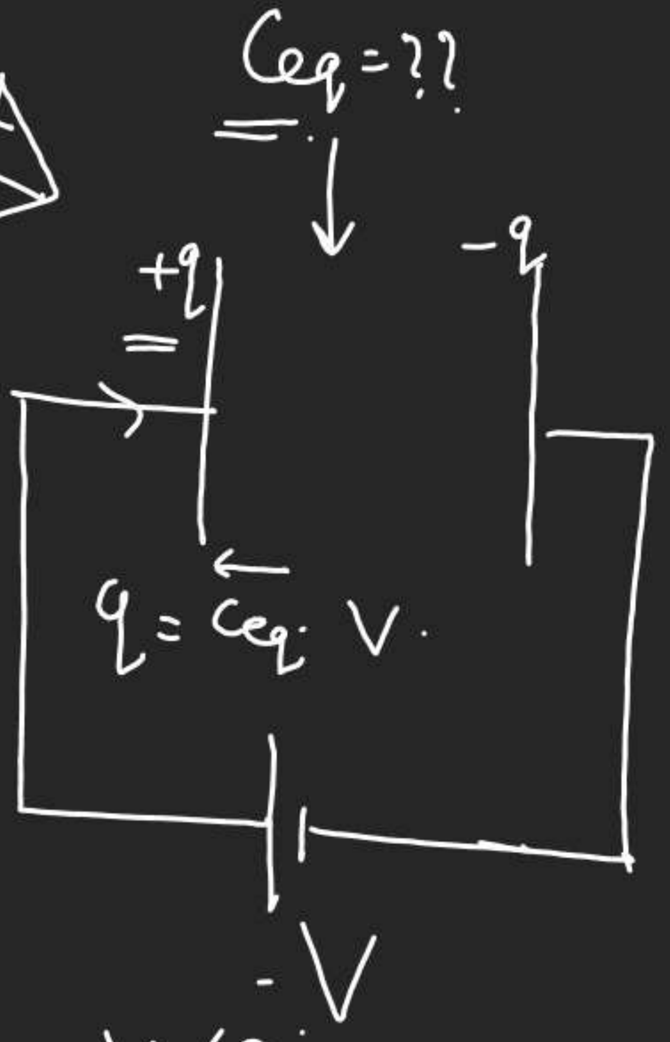
Equivalent Capacitance in Series Combination :-





$$\left[\begin{array}{l} V_1 = \frac{q_1}{C_1} \\ V_2 = \frac{q_2}{C_2} \\ \vdots \\ V_n = q_n / C_n \end{array}\right.$$

$$V = \left(\frac{q}{C_{eq}}\right)$$

$$V = V_1 + V_2 - - - + V_n$$

$$\frac{q}{C_{eq}} = \frac{q}{C_1} + \frac{q}{C_2} - - - + \frac{q}{C_n} \Rightarrow \boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} - - - + \frac{1}{C_n}}$$

**

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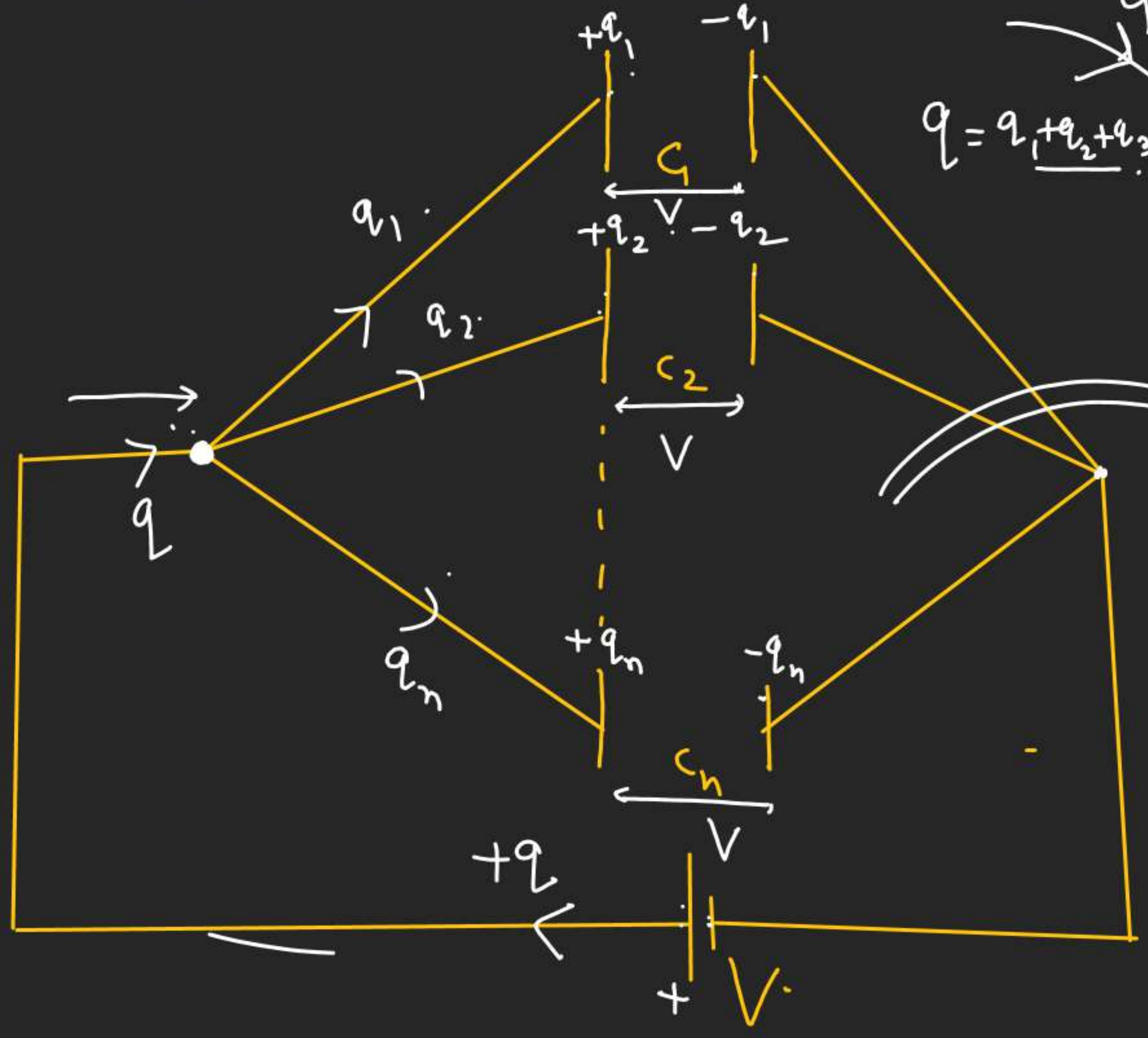
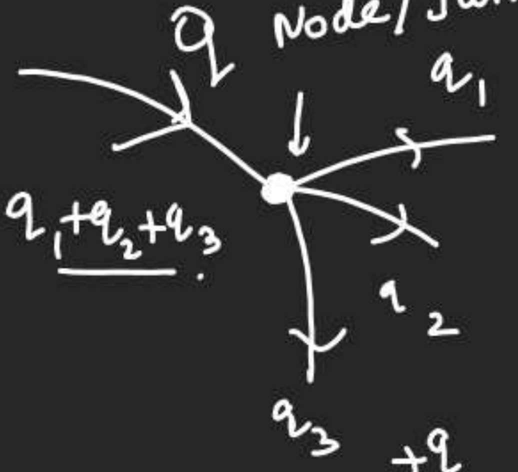
(*) Parallel Combination:-



Node/Junction



$$q = q_1 + q_2 + q_3$$

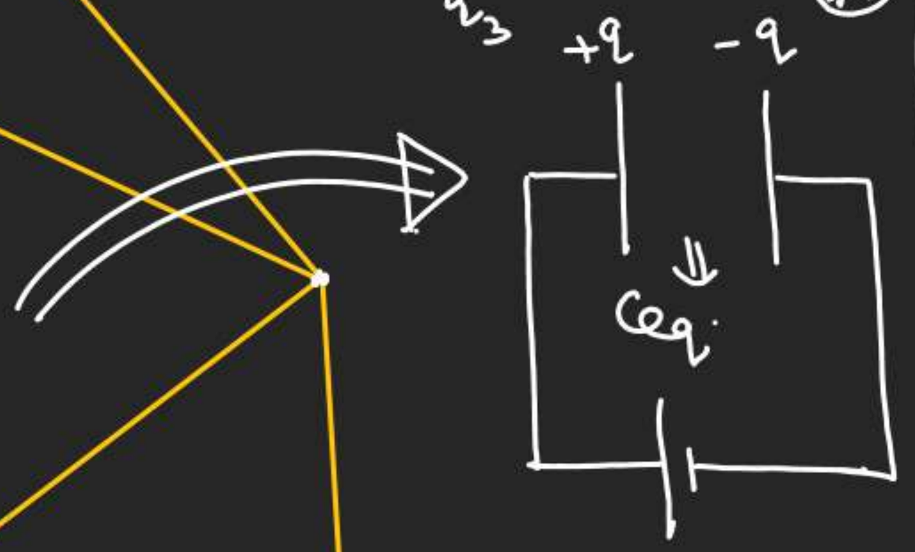
$$q_1 = C_1 V,\ q_2 = C_2 V,\ q_n = C_n V$$

$$q = q_1 + q_2 \ldots + q_n.$$

$$\Downarrow$$

$$C_{eq} V = C_1 V + C_2 V \ldots + C_n V$$

(*) $$\boxed{C_{eq} = C_1 + C_2 \ldots + C_n}$$



$$q = C_{eq} \cdot V$$

V

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** Dielectric

↳ [Whose Conductivity lying b/w Conductor and Insulator]

* Dielectric in an external Electric field :–

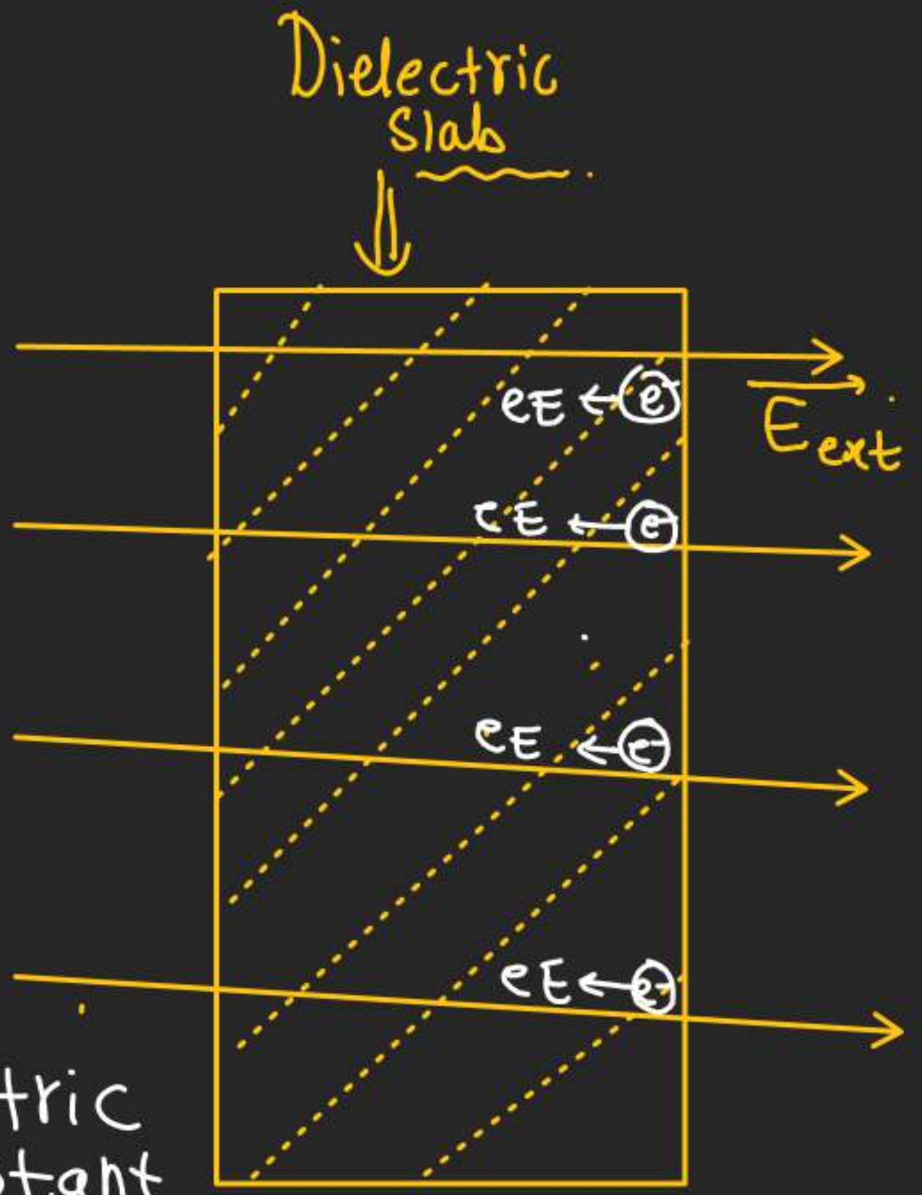
$-q_{ind}$ $+q_{ind}$

$E_{ind} = ??$

E_{ext}

$$E_{net} = \left(\frac{E_{ext}}{K}\right)$$

K → Dielectric Constant



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

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

**

$$\boxed{E_{ind} = E_{ext}\left[1 - \frac{1}{K}\right]}$$

$K \to \infty \Rightarrow$ For Conductor

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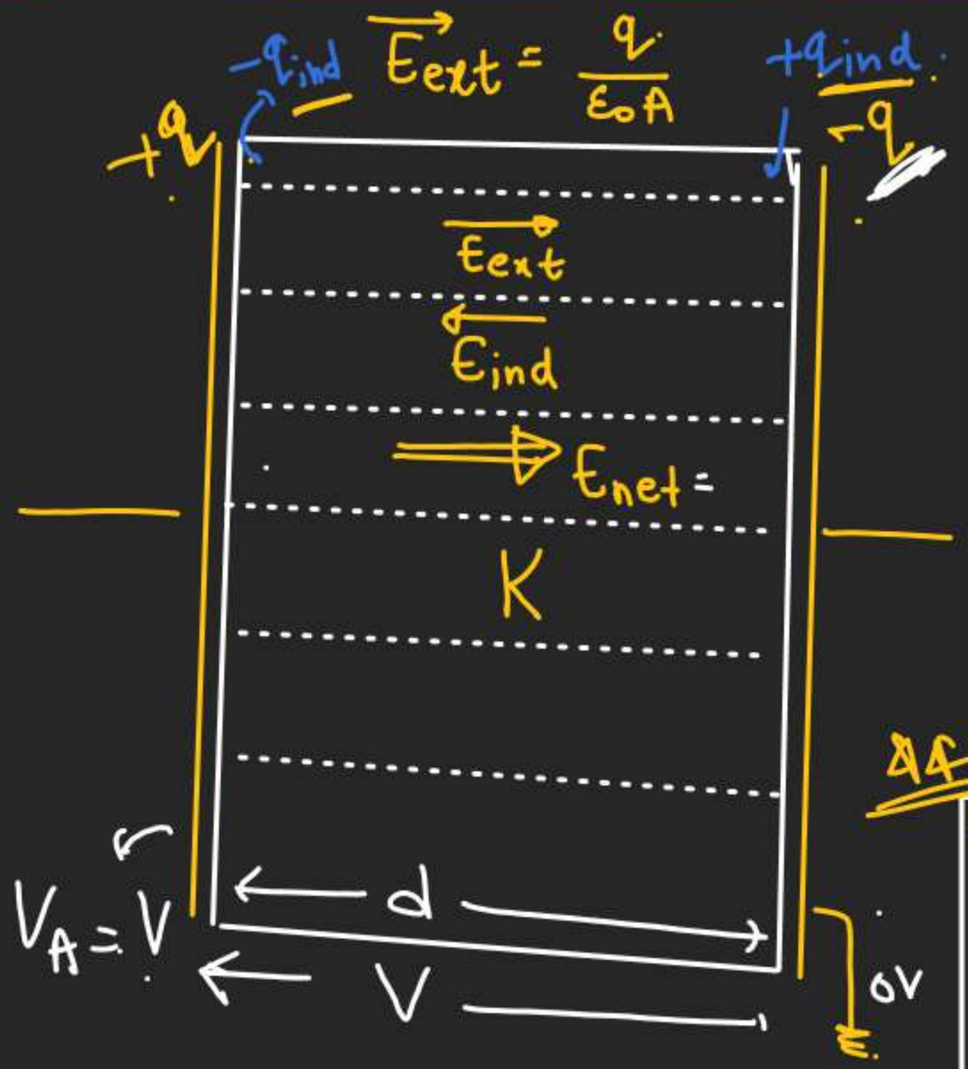
(A) **Parallel plate Capacitor with dielectric** → **Capacitance of Parallel plate Capacitor with dielectric**



$$E_{net} = \frac{E_{ext}}{K} = \left(\frac{q}{K\varepsilon_0 A}\right)$$

$$E_{ind} = E_{ext}\left[1 - \frac{1}{K}\right]$$

$$\Downarrow$$

$$\frac{q_{ind}}{\varepsilon_0 A} = \frac{q}{\varepsilon_0 A}\left[1 - \frac{1}{K}\right]$$

$$\boxed{q_{ind} = q\left[1 - \frac{1}{K}\right]}$$

$\boxed{K > 1}$

$K \to \infty$, $q_{ind} = q$ ⇐ In Conductor

(A)

$$V = \left(\frac{E_{ext}}{K}\right)(d)$$

$\Downarrow E_{net}$

$$V = \frac{q}{\varepsilon_0 A}\frac{d}{K}$$

$$q = \left(\frac{K\varepsilon_0 A}{d}\right) V$$

$\Longrightarrow C_{dielectric}$

$$\boxed{C_{dielectric} = K\, C_{air}}$$

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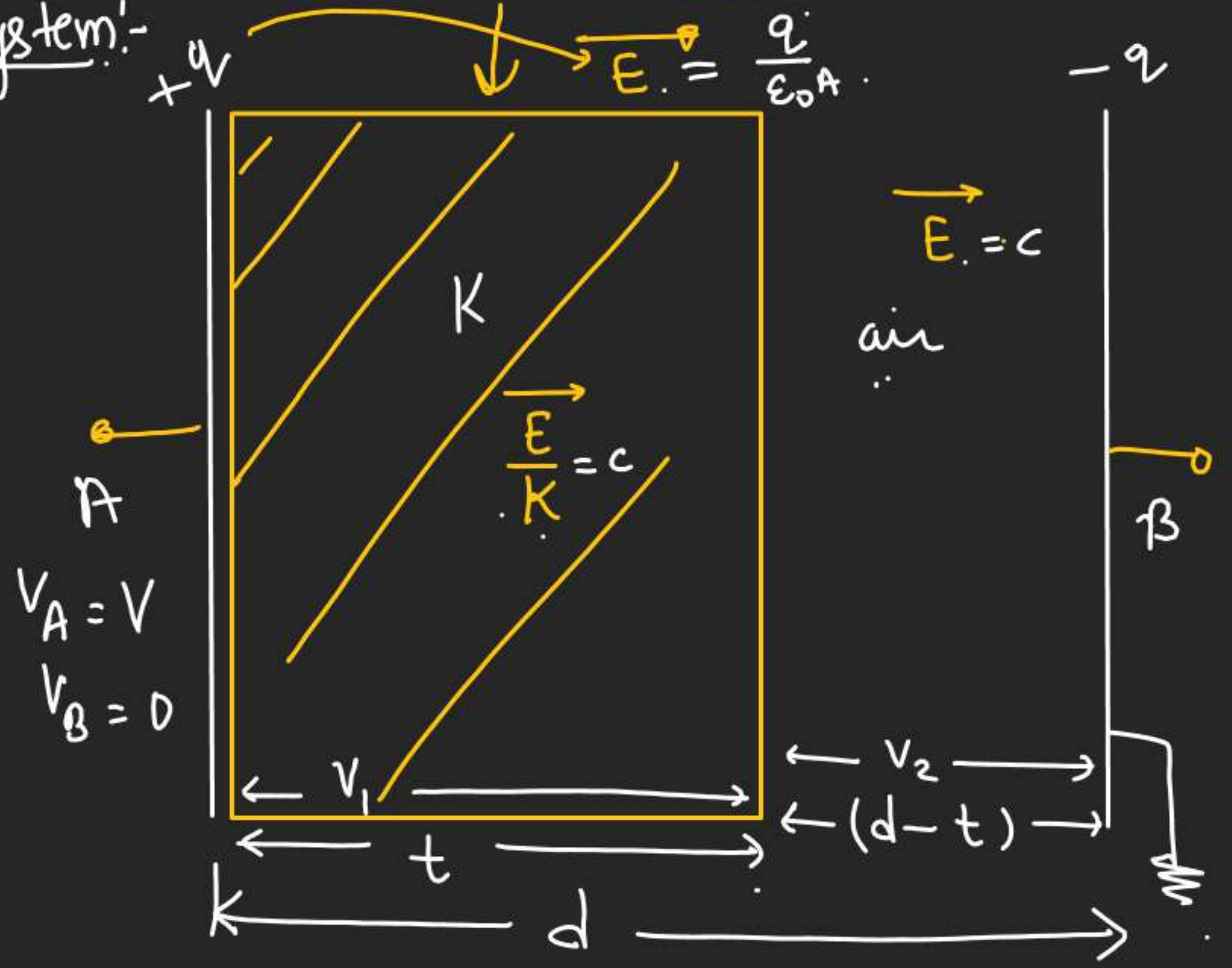
\# Find the Capacitance of the System:- Dielectric



$V_A - \cancel{V_B}^{\,0} =$

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

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

$$V = \frac{q}{\varepsilon_0 A}\left[(d-t) + \frac{t}{K}\right]$$

$$q = \left[\frac{\varepsilon_0 A}{(d-t)+\frac{t}{K}}\right] \cdot V$$

$$q = C \quad V$$

$$\boxed{C = \frac{\varepsilon_0 A}{(d-t)+\frac{t}{K}}}$$

Effective distance in air

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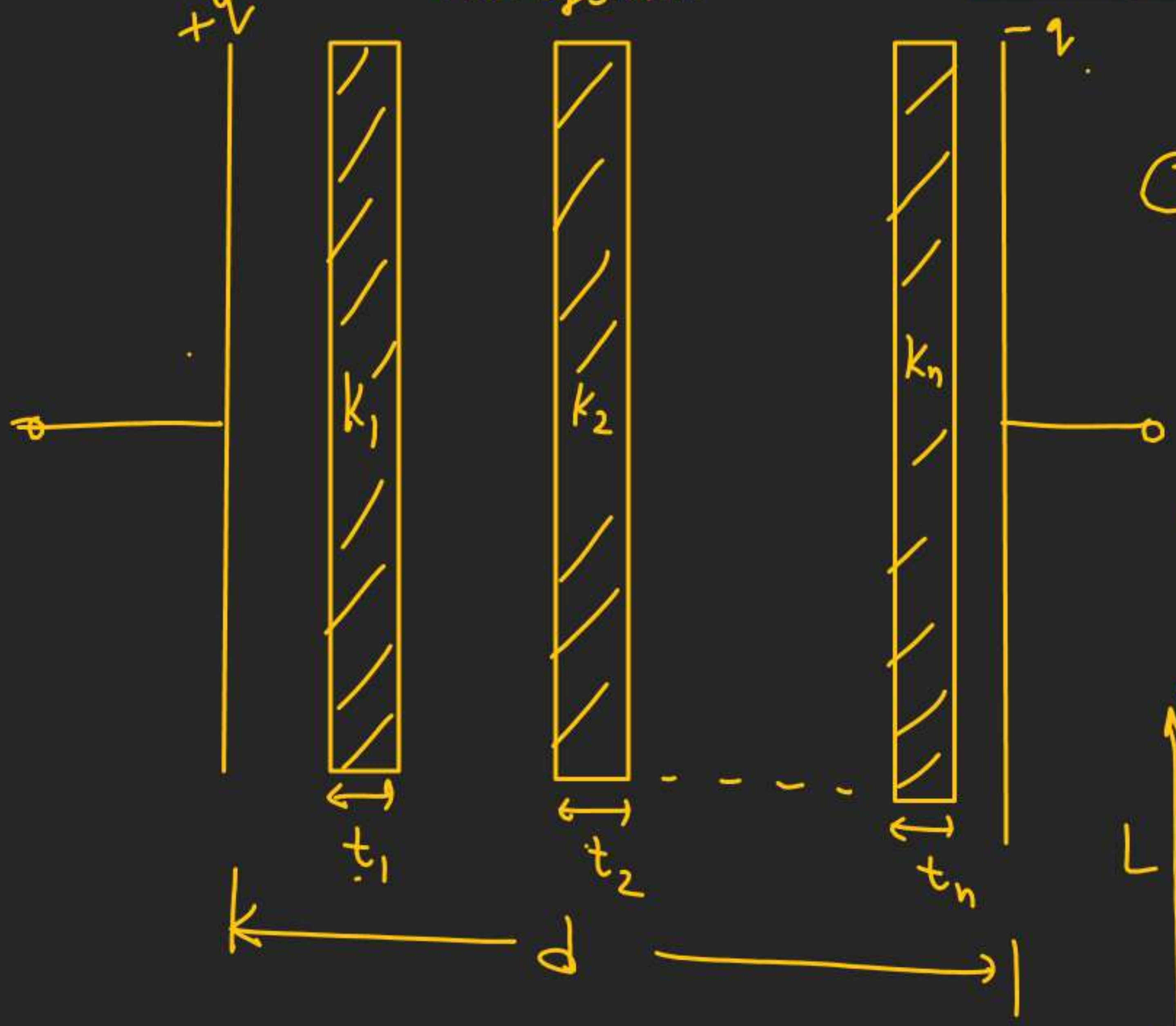
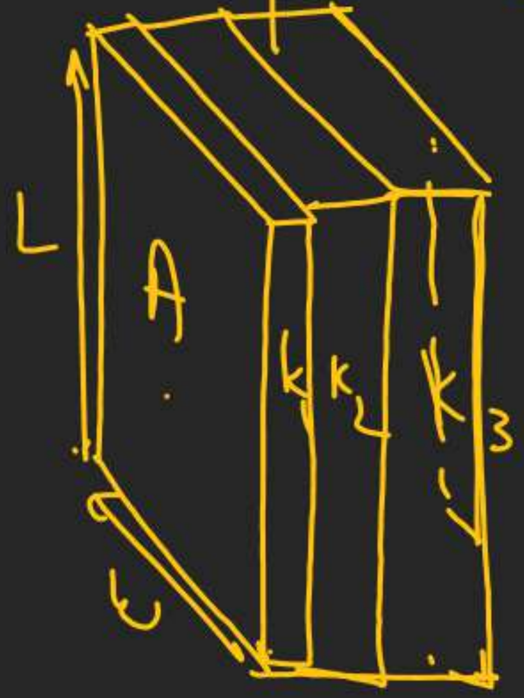
Find Capacitance of the System.



$$C = \frac{\varepsilon_0 A}{\left[d - (t_1 + t_2 \dots + t_n)\right] + \left(\frac{t_1}{k_1} + \frac{t_2}{k_2} \dots + \frac{t_n}{k_n}\right)}$$

$$C = \left[\frac{\varepsilon_0 A}{\left(d - \sum_{i=1}^{n} t_i\right) + \sum_{i=1}^{n} \frac{t_i}{k_i}}\right]$$



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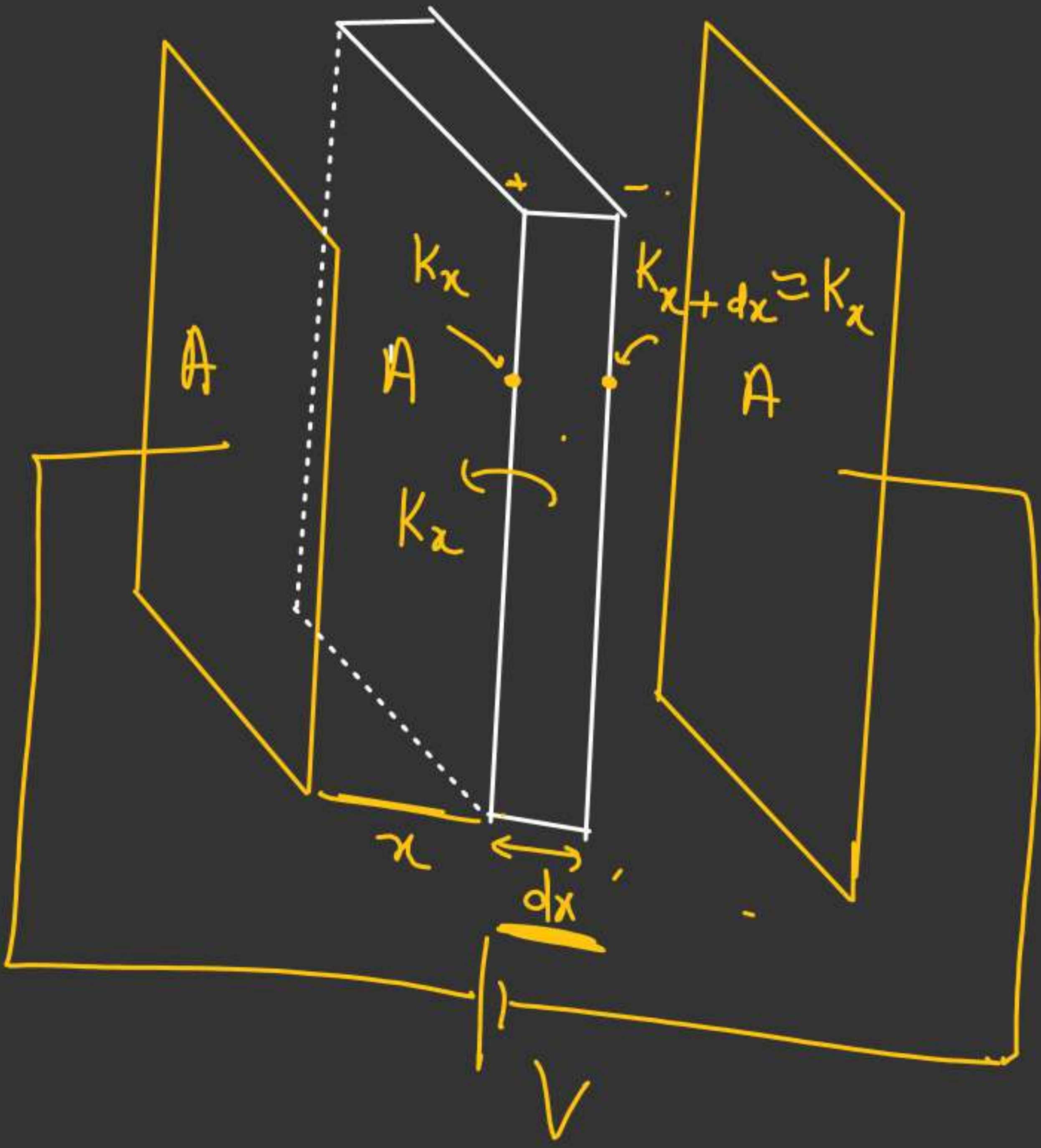
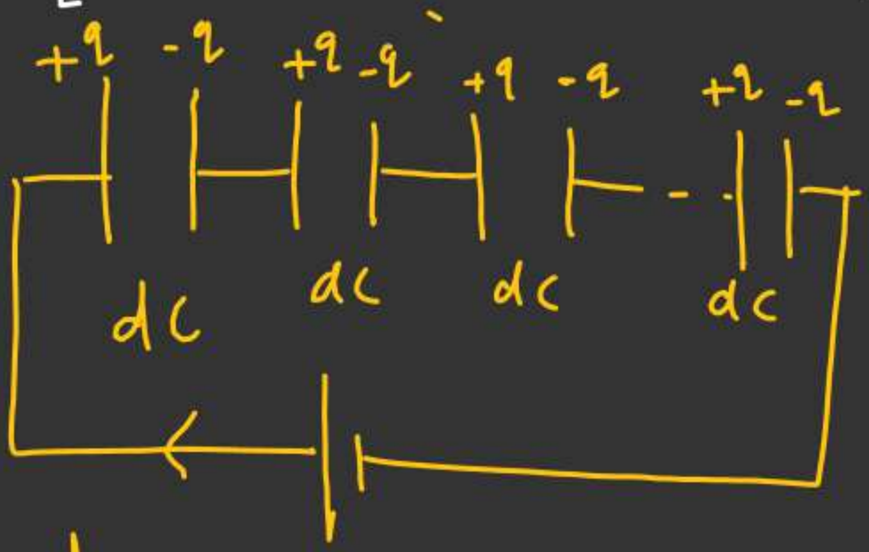
Capacitance of a parallel plate capacitor with variable dielectric :-

$$K = (a+bx)$$

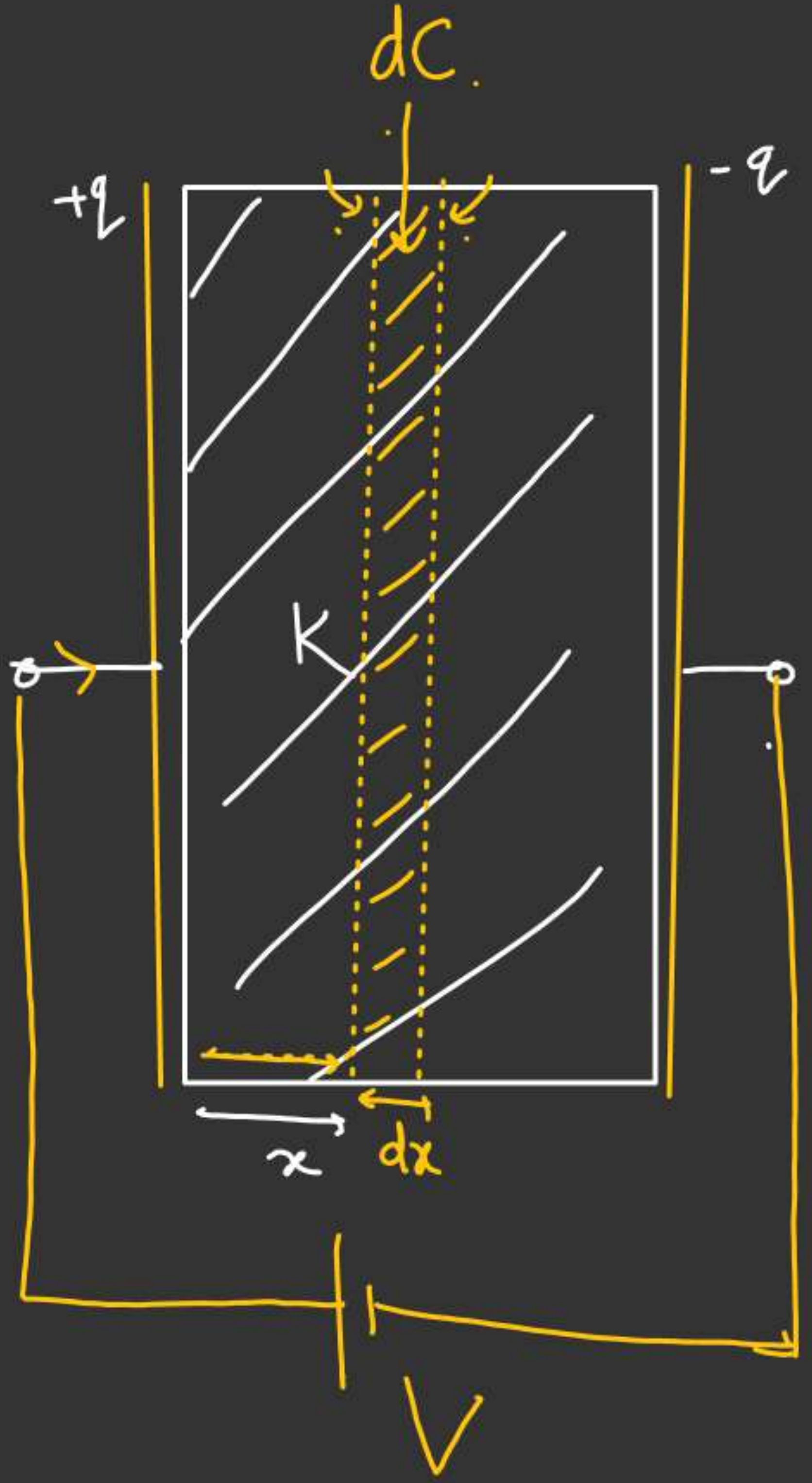
[a & b are Constant]





$$dC = \frac{K_x \varepsilon_0 A}{dx}$$

$$dC = \frac{(a+bx)\,\varepsilon_0 A}{dx}$$



Capacitor

$$dC = \frac{K_x \varepsilon_0 A}{dx}$$

$\Downarrow$

dC_{eq}

$K_x = (a+bx)$

$$\boxed{\int \frac{dx}{x} = \ln x \quad \Bigg| \quad \int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx)}$$

$$\frac{1}{dC_{eq}} = \frac{1}{dC}$$

$$\int_0^{C_{eq}} \frac{1}{dC_{eq}} = \int_0^{d} \frac{dx}{(a+bx)} \times \frac{1}{\varepsilon_0 A} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{\varepsilon_0 A}\int_0^{d} \frac{dx}{a+bx}$$

$$\frac{1}{C_{eq}} = \frac{1}{\varepsilon_0 A} \ln(a+bx]_0^{d}$$

$$\frac{1}{C_{eq}} = \frac{1}{\varepsilon_0 A} \ln\left[\frac{a+bd}{a}\right] \Rightarrow C_{eq} = \frac{\varepsilon_0 A \cdot a}{\ln(a+bd)}$$

Ans

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H.W.

$\left(K = K_0 y^2\right)$ — K_0 → constant.

$C = ??$

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