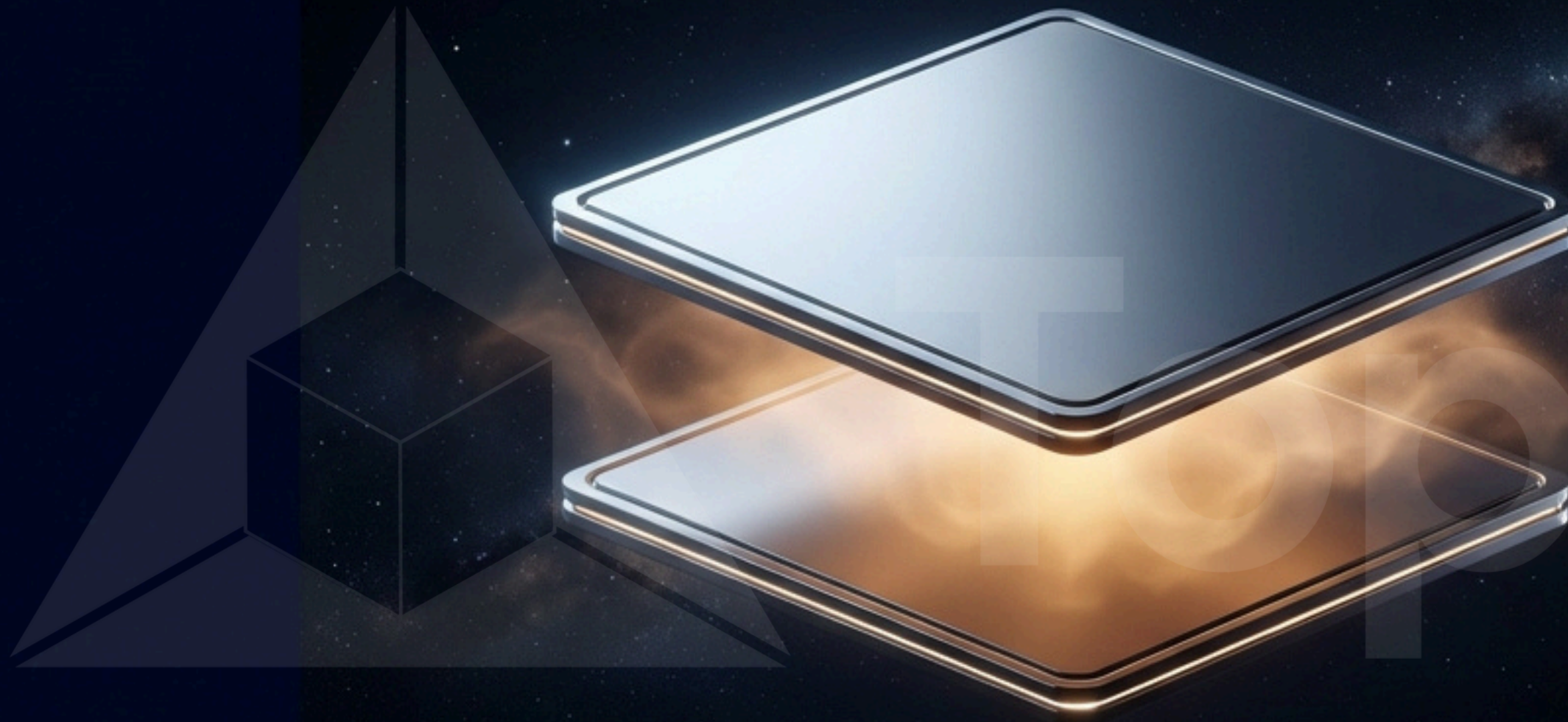


The Most Important Capacitor Formula In Electrostatics



Unlocking the geometry of stored electrical energy.



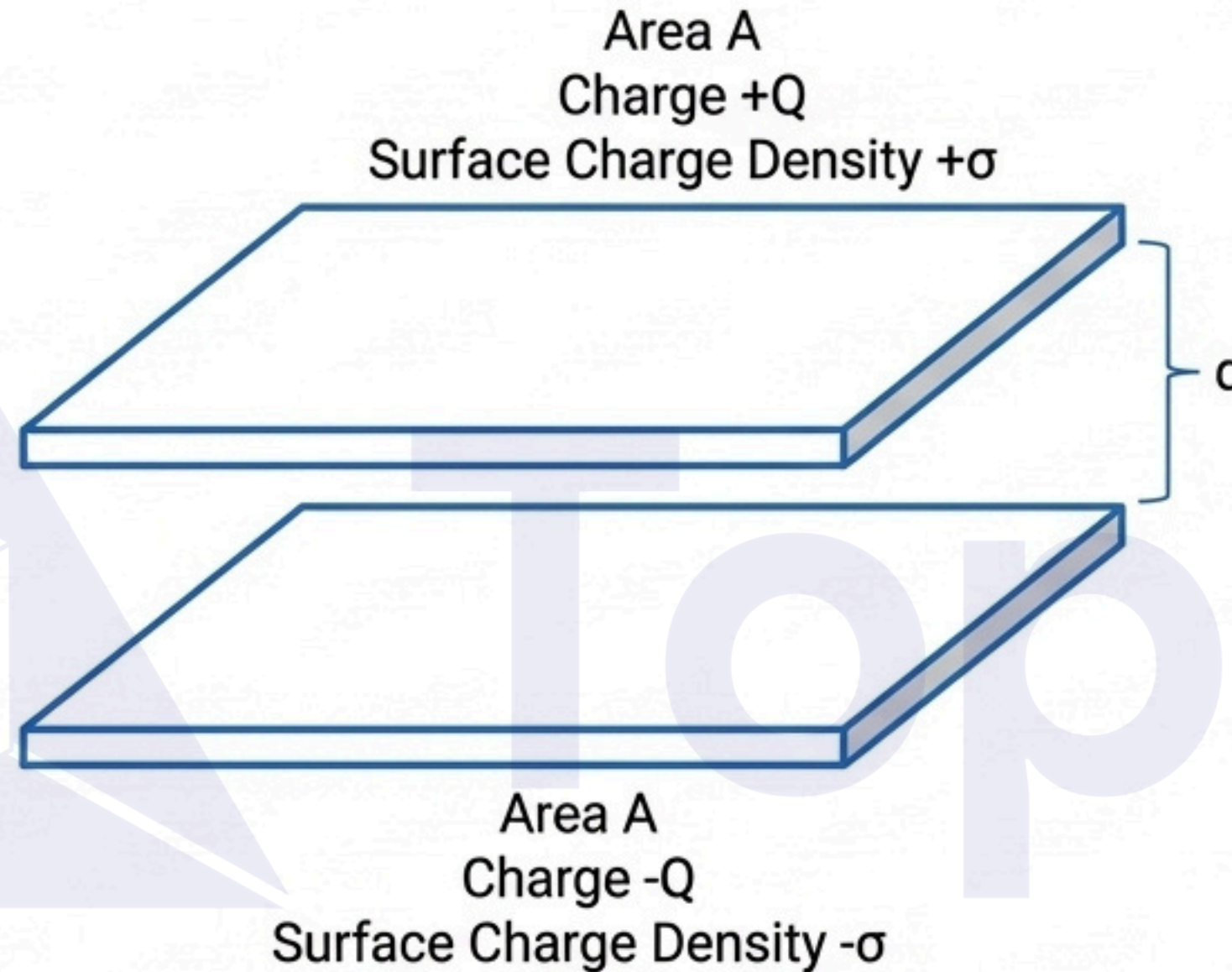
Target: Mastering textbook Section 2.12 (Derivation & Concepts)

Practice more, score more

Defining The Geometry (Fig 2.25)

The Plates

- Two large plane parallel conducting plates.
- Cross-sectional Area = A .



The Gap

- Separated by a small distance in vacuum = d .
- Crucial assumption: $d^2 \ll A$ (Plates are functionally infinite compared to the gap).

Surface Charge Density: $\sigma = Q/A$

Where Does The Field Go?

Region I:
Above Plate 1



$$\mathbf{E} = \frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0} = 0$$

Eq 2.39: Perfect Cancellation

Inner Region:
Between Plates



Both fields point DOWN (positive to negative). They add up!

Region II:
Below Plate 2



$$\mathbf{E} = \frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0} = 0$$

Eq 2.40: Perfect Cancellation



**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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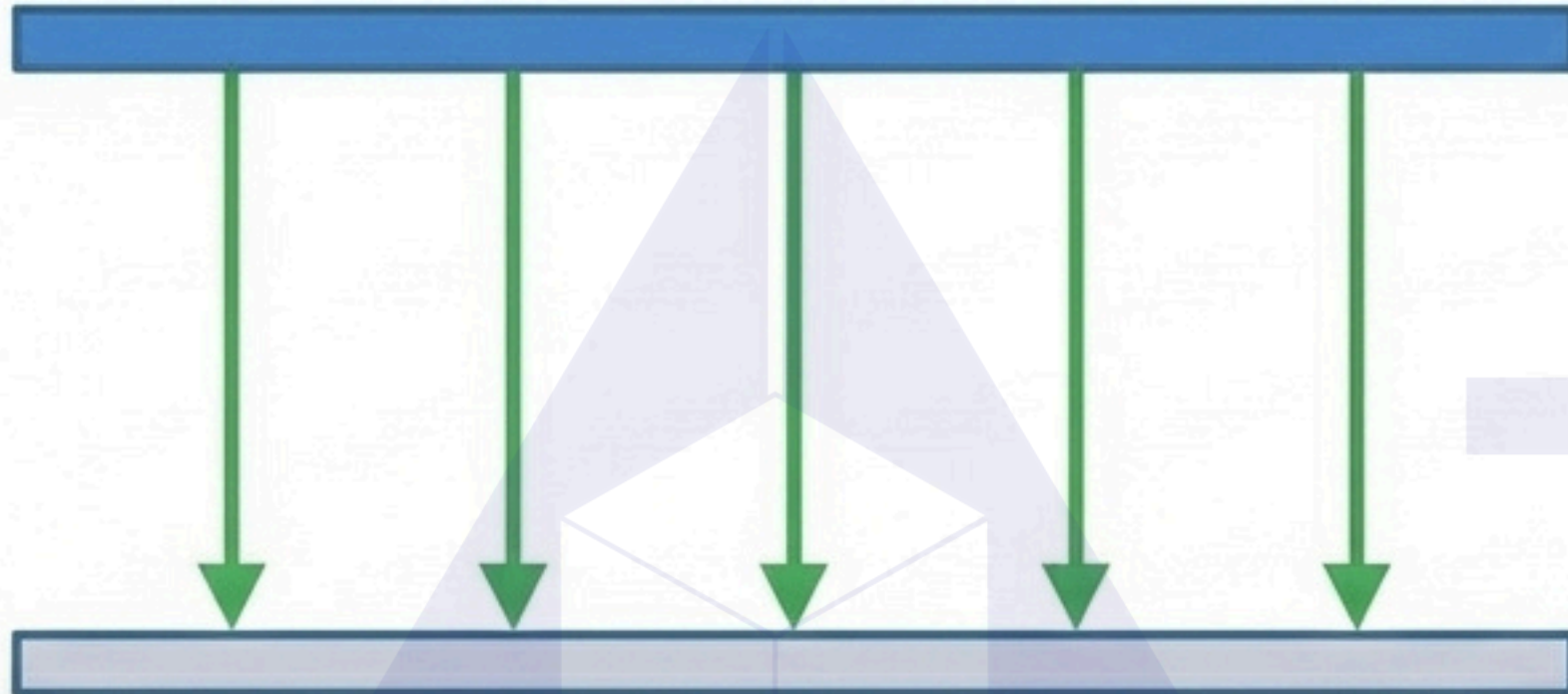
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The Inner Region: A Uniform Field



Insight: The field is localized and strictly uniform throughout the inner region.

Step 1: The Addition (Eq 2.41)

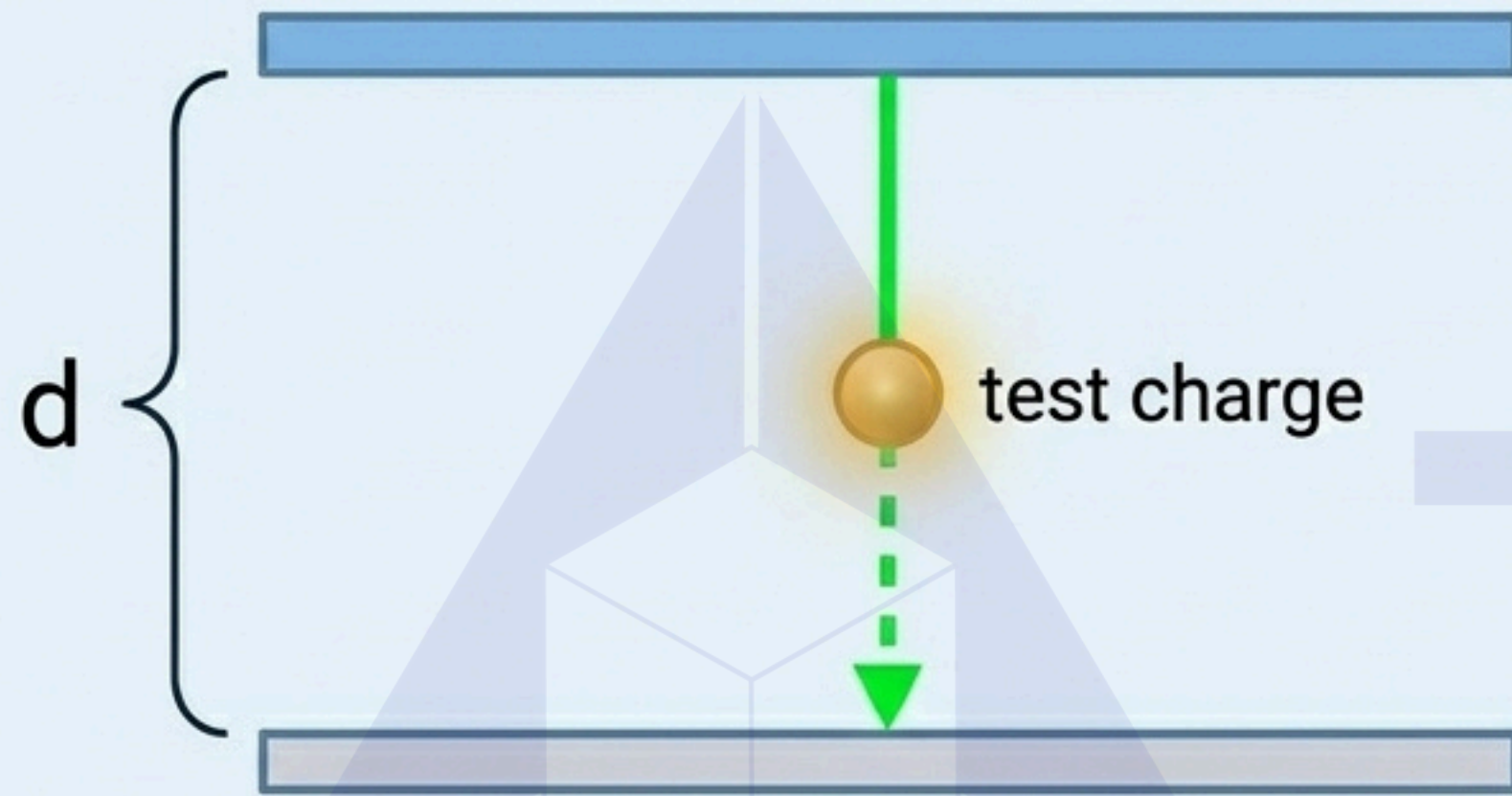
$$\mathbf{E} = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$$

Step 2: Substitute Charge Density

$$\text{Since } \sigma = Q/A$$

$$\mathbf{E} = Q/(\epsilon_0 A)$$

From Field To Potential Difference



For a strictly uniform electric field, Potential Difference (V) is simply the field strength multiplied by the distance.

The Equation (Eq 2.42)

$$V = E \times d$$

The Substitution

Substitute $E = Q / (\epsilon_0 A)$



$$V = \frac{1}{\epsilon_0} \times \frac{Qd}{A}$$

The Capacitance Formula

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

$$C = \frac{Q}{\left[\frac{Qd}{\epsilon_0 A} \right]}$$



(Eq 2.43)

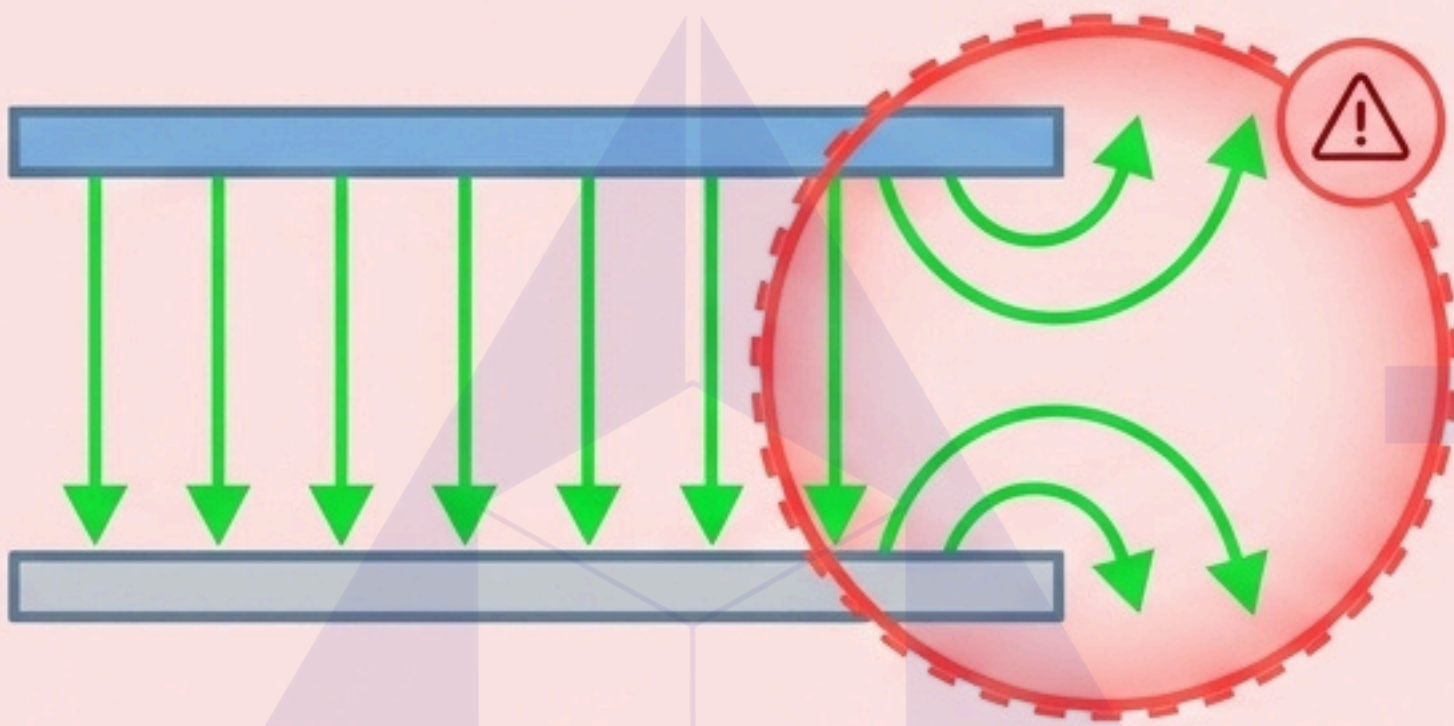
Directly Proportional:
Larger area = more
room for charge. (↑)

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

Inversely Proportional:
Smaller gap = stronger
attraction holding
charges in place. (↓)

The Fringing Effect & Key Takeaways

Exam Trap: The Fringing Effect



- **Reality Check:** At the outer boundaries, field lines bend outward. σ is not strictly uniform at the edges.
- **Why we ignore it:** Because $d^2 \ll A$, we safely ignore this edge effect for textbook derivations.

Key Takeaways

- **Cancel external fields:** $E = 0$ everywhere outside the plates.
- **Add internal fields:** $E = \sigma/\epsilon_0$ strictly between the plates.
- **Relate V and E:** $V = E \times d$ (works only for uniform fields).
- **Memorize the core formula:**

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



You've Learned the Theory.

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