Module 11: Capacitors and Dielectrics

Demonstration: Dissectible Capacitor

Dielectrics

A dielectric is a non-conductor or insulator

Examples: rubber, glass, waxed paper

When placed in a charged capacitor, the dielectric reduces the potential difference between the two plates

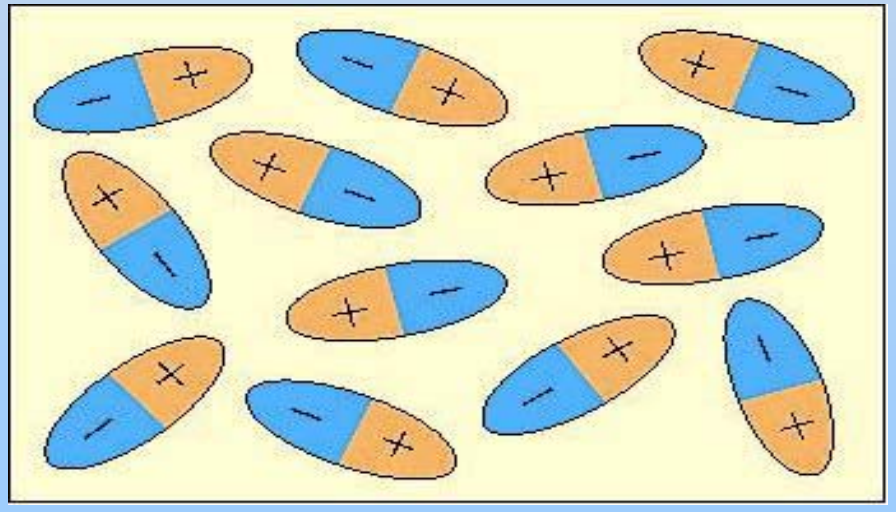
HOW???

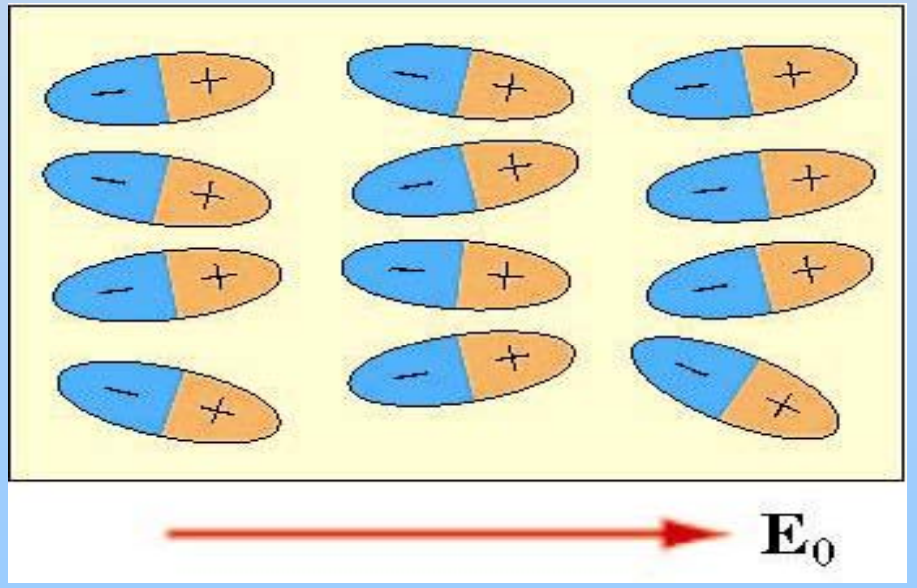
Molecular View of Dielectrics

Polar Dielectrics :

Dielectrics with permanent electric dipole moments

Example: Water



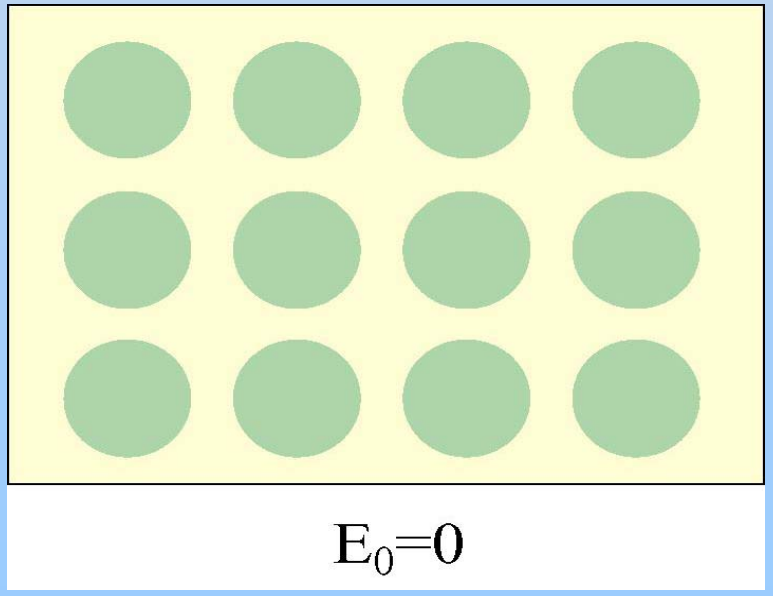


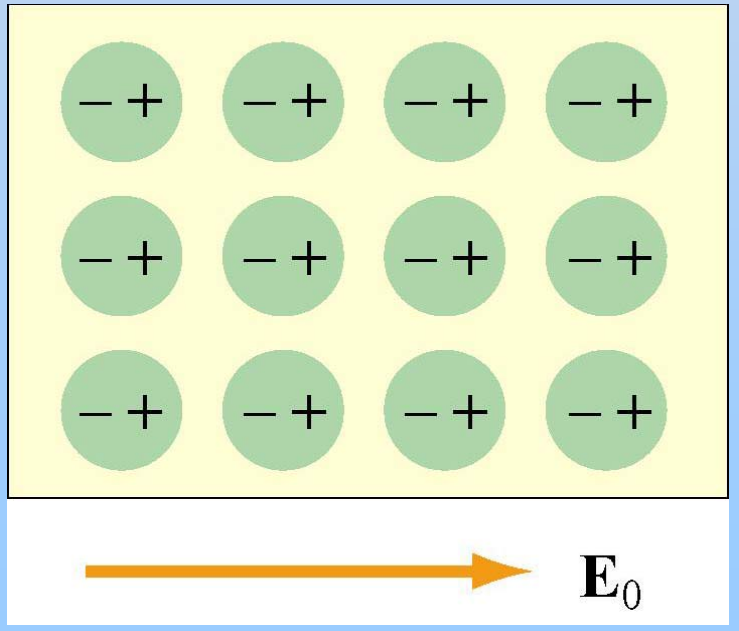
Molecular View of Dielectrics

Non-Polar Dielectrics

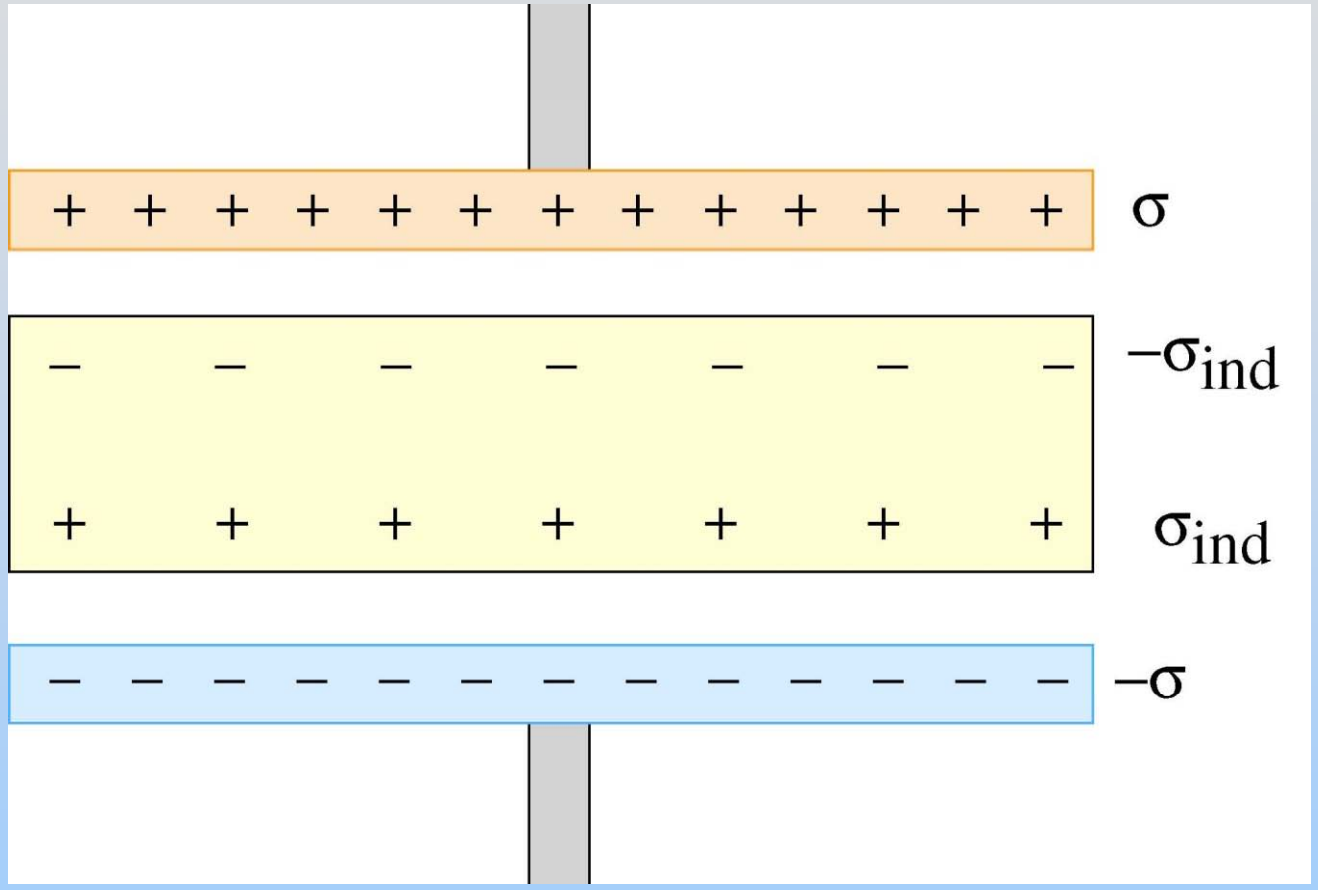
Dielectrics with induced electric dipole moments

Example: CH_4





Dielectric in Capacitor



Potential difference decreases because dielectric polarization decreases Electric Field!

Dielectric Constant κ

Dielectric *weakens* original field by a factor κ

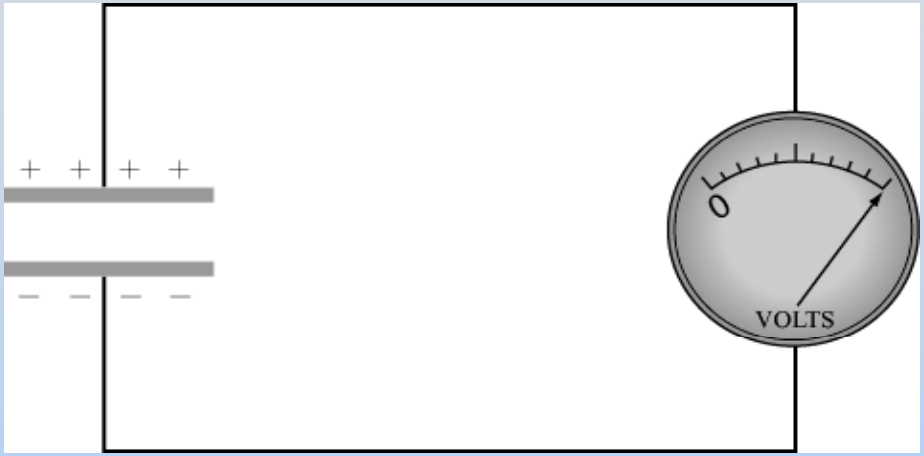
$$\varepsilon = \kappa \varepsilon_0 \longrightarrow E = \frac{E_0}{\kappa}$$

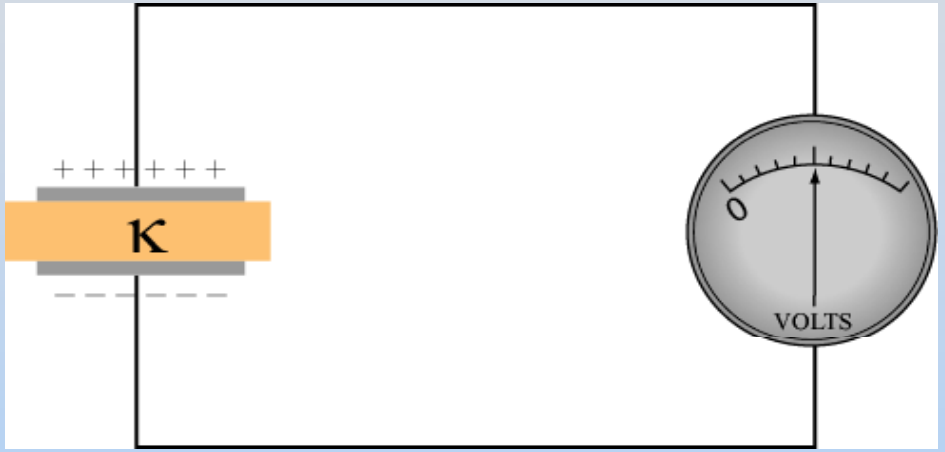
Dielectric Constant

Dielectric constants	
Vacuum	1.0
Paper	3.7
Pyrex Glass	5.6
Water	80

Dielectric in a Capacitor

Q_0= constant after battery is disconnected



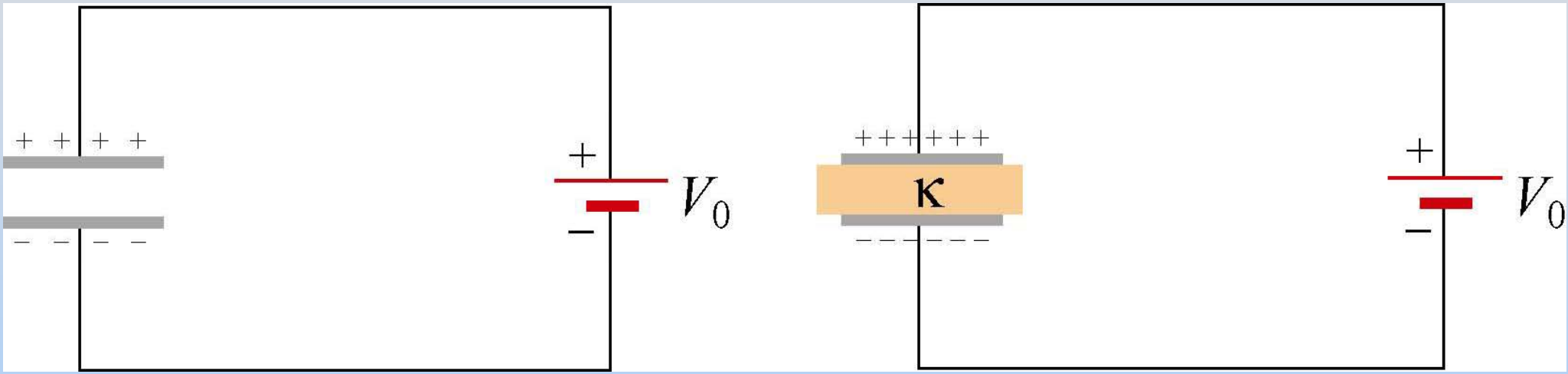


Upon inserting a dielectric: $V = \dfrac{V_0}{\kappa}$

$$C = \frac{Q}{V} = \frac{Q_0}{V_0 / \kappa} = \kappa \frac{Q_0}{V_0} = \kappa C_0$$

Dielectric in a Capacitor

V_0 = constant when battery remains connected



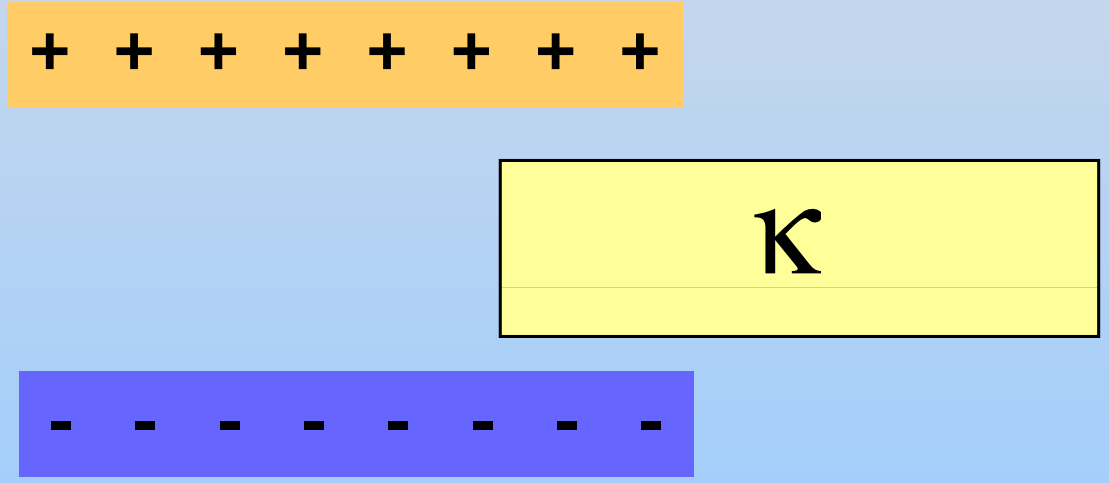
$$Q = CV = \kappa C_0 V_0$$

Upon inserting a dielectric: $Q = \kappa Q_0$

Concept Question Questions: Dielectric in a Capacitor

Concept Question: Dielectric

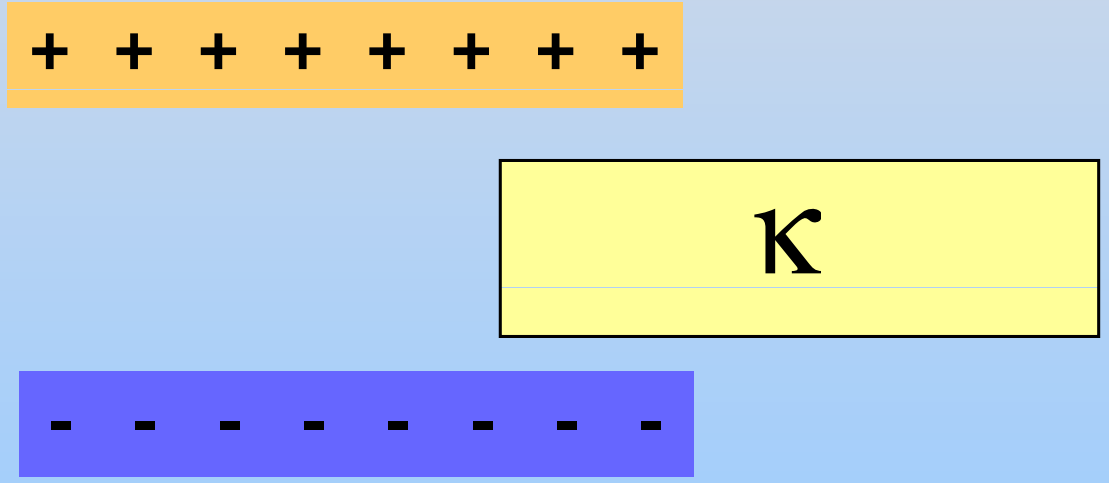
A parallel plate capacitor is charged to a total charge Q and the battery removed. A slab of material with dielectric constant κ in inserted between the plates. The **charge** stored in the capacitor



1. Increases
2. Decreases
3. Stays the Same

Concept Question: Dielectric

A parallel plate capacitor is charged to a total charge Q and the battery removed. A slab of material with dielectric constant κ in inserted between the plates. The **energy** stored in the capacitor



1. Increases
2. Decreases
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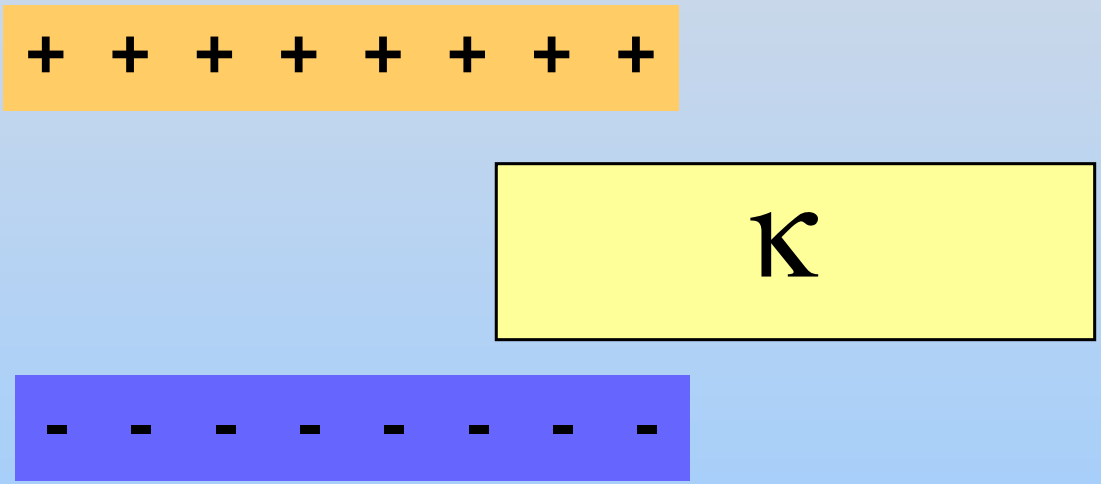
Concept Question: Dielectric

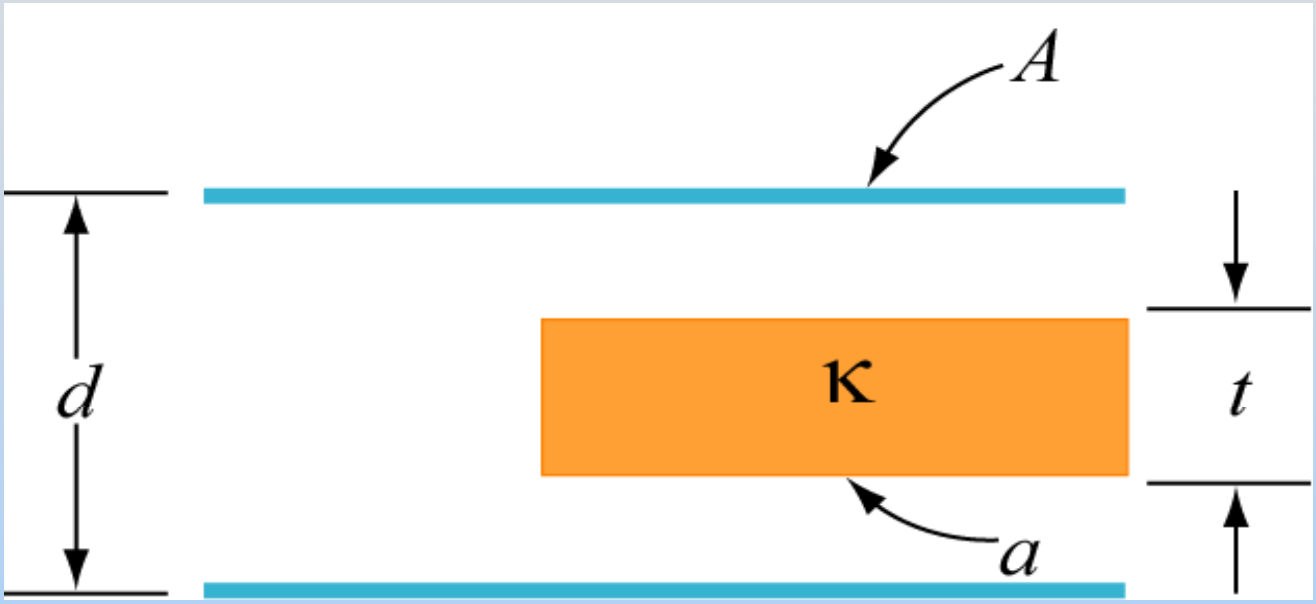
A parallel plate capacitor is charged to a total charge Q and the battery removed. A slab of material with dielectric constant κ in inserted between the plates.

The **force on the dielectric**



1. pulls in the dielectric
2. pushes out the dielectric
3. is zero

Problem: Partially Filled Capacitor



What is the capacitance of this capacitor?

Gauss's Law with Dielectrics

$$\oiint_S \kappa \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q_{\text{free,in}}}{\varepsilon_0}$$

8.02SC Physics II: Electricity and Magnetism

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