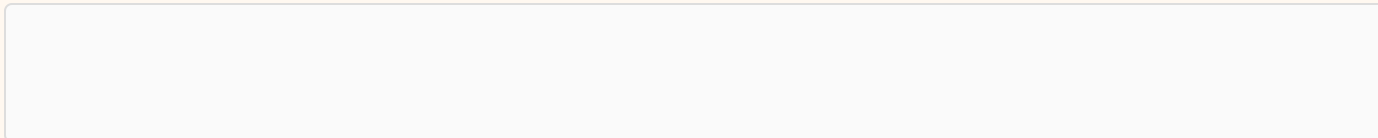


CAPACITORS DAY 4: DIELECTRICS

WARMUP The Balloon on the Wall

A rubbed balloon (negatively charged) sticks to a NEUTRAL wall. No charge jumps across — the wall's molecules stretch. Sketch one wall molecule: which end faces the balloon, and what does the whole layer of stretched molecules build at the wall's surface? (Today the same stretch fills a capacitor.)



DIELECTRICS: POLARIZATION FIGHTS THE FIELD

An insulator's molecules stretch in the field; bound surface charge appears and bucks the applied field: $\mathbf{E} = \mathbf{E}_0/\kappa$ inside (κ = dielectric constant > 1). Filling the gap:

$$\mathbf{C} = \kappa \mathbf{C}_0 \text{ — always.}$$

Charge trapped (disconnected): Q fixed $\rightarrow V = V_0/\kappa$, $U = U_0/\kappa$ (the slab gets pulled in; the field does work on it).

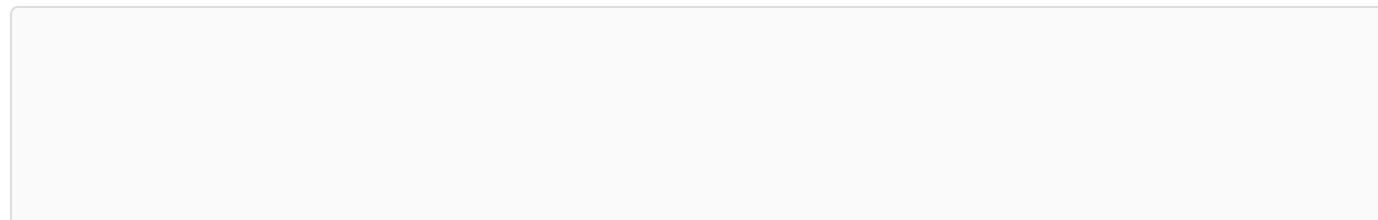
Battery connected: V fixed $\rightarrow Q = \kappa Q_0$, $U = \kappa U_0$ (the battery pays).

Always ask first: what is held fixed — Q or V ?

WE DO Exercise 1: Charge Trapped

A $2.0 \mu\text{F}$ capacitor charged to 120 V is disconnected, then filled with $\kappa = 3$ dielectric. **(a)** $C =$ _____ μF .

(b) Q stays _____ μC . **(c)** New $V =$ _____ V .



BATTERY CONNECTED, AND PARTIAL FILLS

WE DO Exercise 2: Battery Connected

A capacitor holding $24\ \mu\text{C}$ stays connected to its battery while $\kappa = 2.5$ dielectric fills it. **(a)** New $Q = \kappa Q_0 =$ _____ μC . **(b)** V changed by what factor? **(c)** U changed by what factor, and who paid?

YOU DO Exercise 3: Measure κ

Inserting an unknown slab (full fill) raises a capacitor from $50\ \text{pF}$ to $175\ \text{pF}$. Find κ .

CALC Exercise 4: The Partial-Fill Walk

Fixed plate charge gives $E_0 = 60\ \text{V/m}$ across a $d = 2.0\ \text{m}$ gap; a slab (thickness $0.6\ \text{m}$, $\kappa = 3$) sits mid-gap. Compute $\Delta V = \int E\ dx$ piecewise: vacuum stretch + slab stretch = _____ + _____ = _____ V .

PAPER PRACTICE

PRACTICE PROBLEMS

P1 The Multiplier

$\kappa = 4$ dielectric fills a $3.0 \mu\text{F}$ capacitor. New C ?

P2 Trapped Charge

A disconnected capacitor at 90 V is filled with $\kappa = 3$. New voltage?

P3 Energy, Trapped Charge

The same insertion drops the stored energy from $90 \mu\text{J}$ to what? Where did the missing energy GO?

P4 Bound Charge

Plates carry $\sigma = 3.0 \mu\text{C}/\text{m}^2$; a $\kappa = 3$ slab fills the gap. The slab's faces acquire bound charge $\sigma_b = \sigma(1 - 1/\kappa)$. Compute σ_b , and check the direction: does its field oppose or reinforce the plates' field inside the slab?