Capacitance

Energy in a capacitor, examples

- Text sections 26.4, 26.5

Practice: Chapter 26,
Objective Questions 7, 12
Conceptual Question 5
Problems 65, 68, 78

Energy Stored in a Capacitor

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

"Energy density"

$$u_E = \frac{U}{\text{volume}} = \frac{1}{2}\varepsilon_o |\mathbf{E}|^2$$

We can think of this energy as ***stored in the electric field*** set up when the capacitor is charged:

Parallel-Plate Capacitor: $C = \dfrac{\varepsilon_o A}{d}$ and $V = E \cdot d$

$$\Rightarrow \quad U = \frac{1}{2} C V^2 = \frac{1}{2} \varepsilon_o E^2 \cdot \underbrace{(Ad)}_{\text{Volume between plates}}$$

"Energy density"

$$u_E = \frac{U}{\text{volume}} = \frac{1}{2} \varepsilon_o |\mathbf{E}|^2$$

(Units: J/m^3)

This also applies to *any* electric field.

What are capacitors used for?

-energy storage (small amounts, for short times)

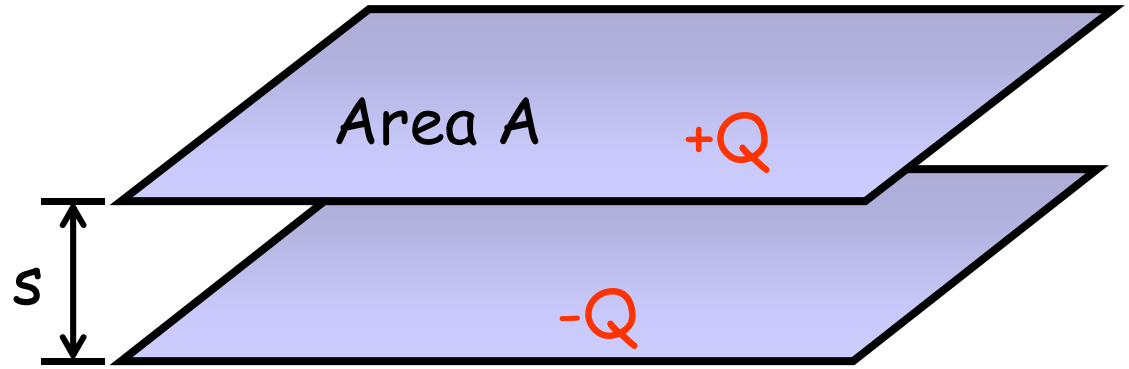
-delivering high current and power for short times

-filtering out voltage fluctuations in power supplies

-separating frequencies in electrical signals

-time delay circuits

Exercise



Calculate:

a) $\vec{E}$ between plates

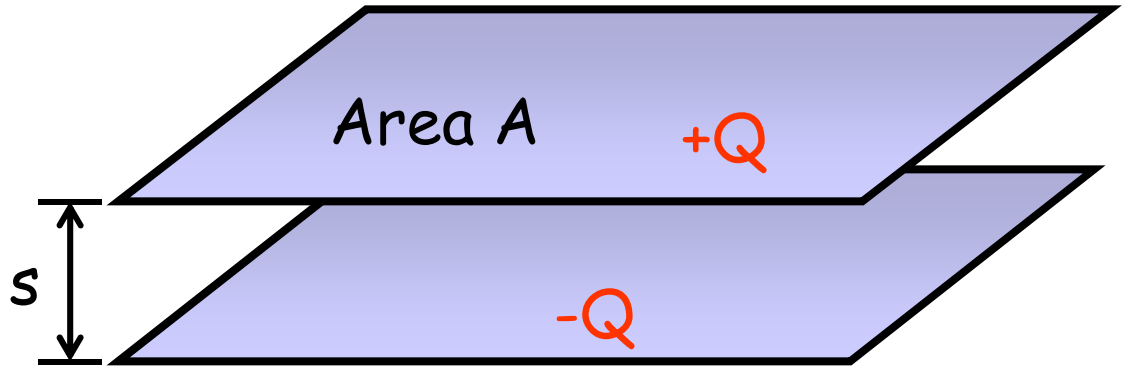
b) ΔV between plates

c) C between plates

d) U of the system

e) Force exerted on top plate *(tricky...)*

Quiz



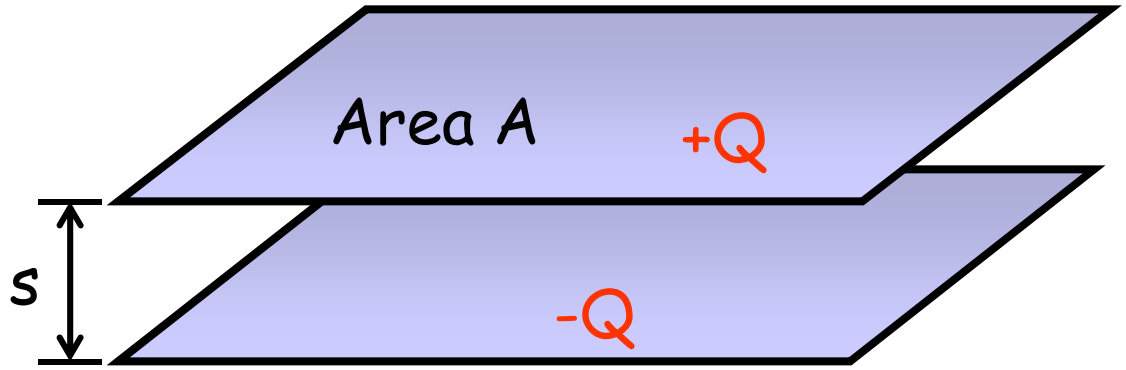
The plates are charged, and then disconnected from the battery. When they are moved apart an extra distance Δs, the potential energy

A) increases

B) decreases

C) remains constant

Quiz



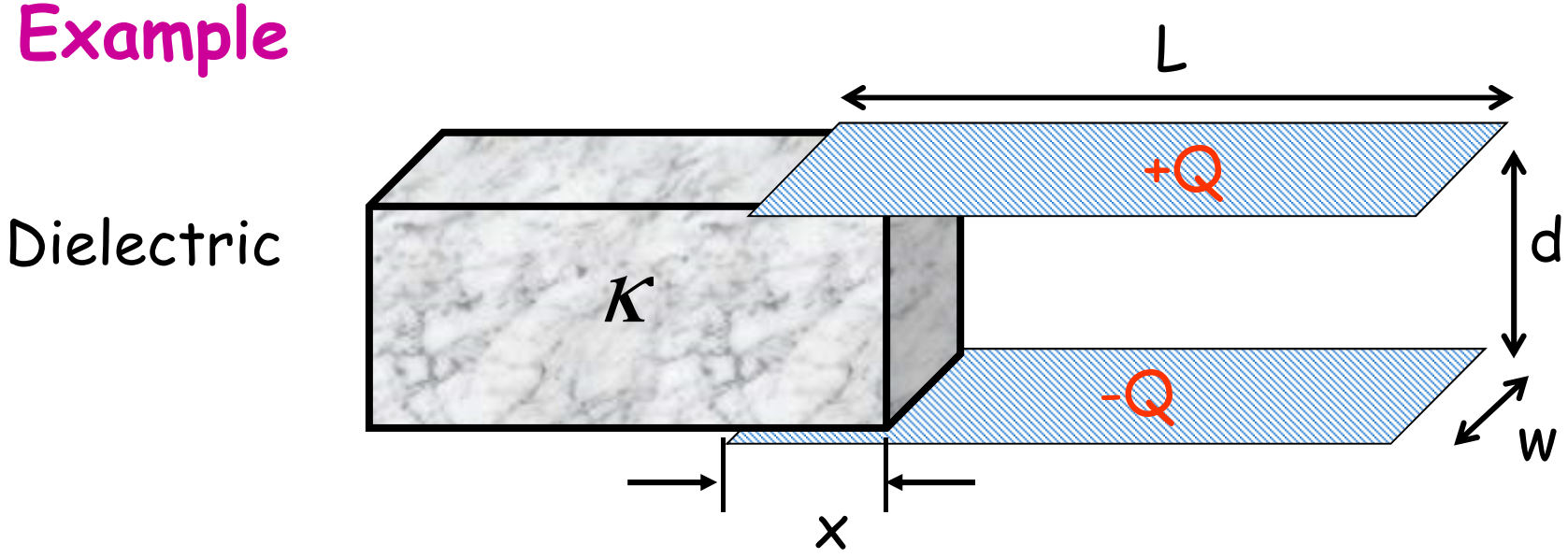
When the plates are moved apart an extra distance Δs, the work done ***by the electric forces*** *is*

A) positive

B) negative

C) zero

Example



A dielectric is slid into the space between the plates of a charged capacitor.

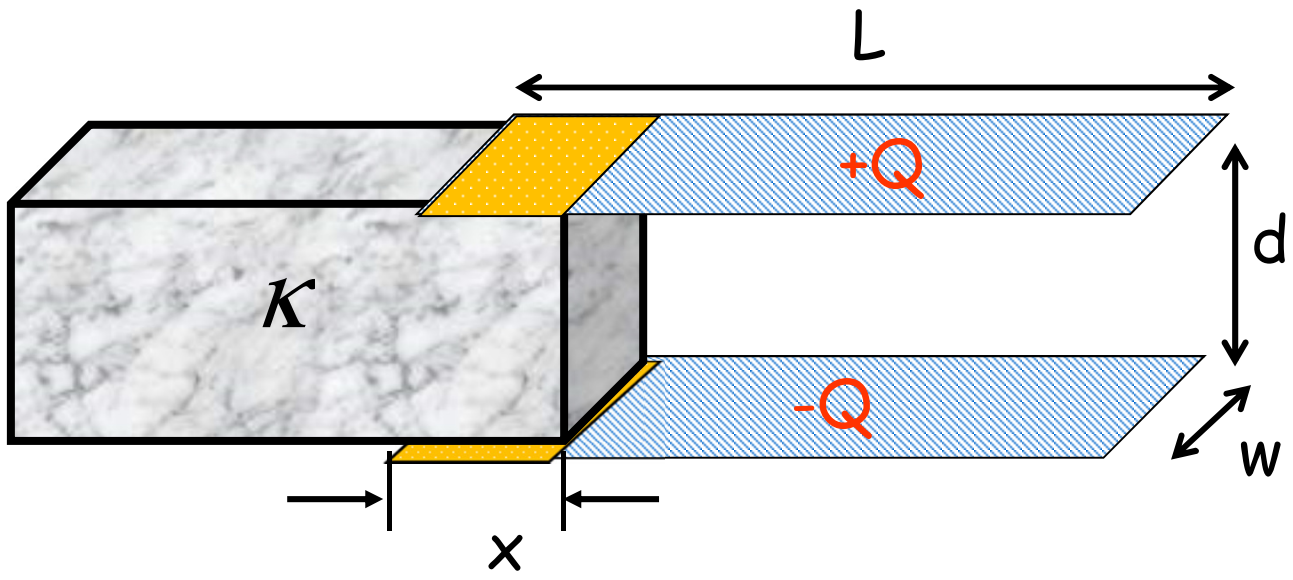
Find: 1) Capacitance as a function of *x*

2) P.E. in capacitor as a function of *x*.

3) Force on dielectric due to field of capacitor.

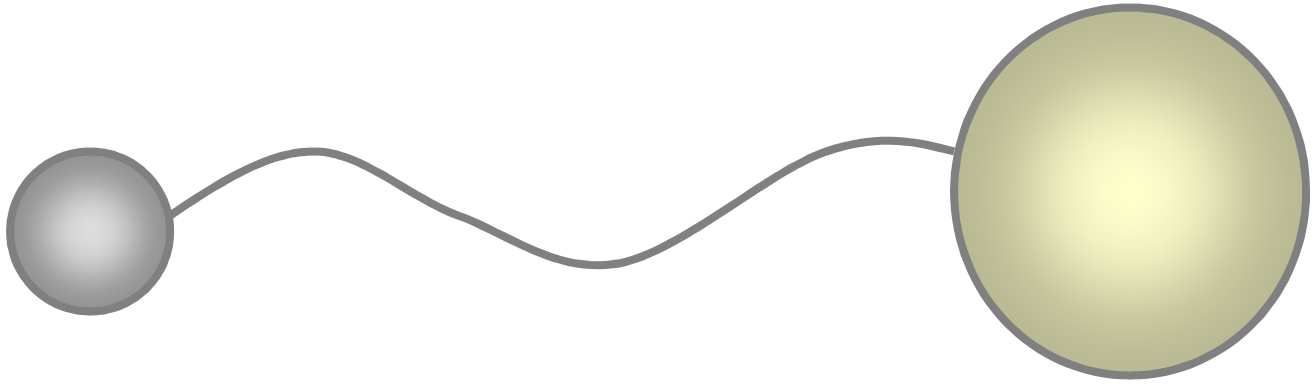
Example

Dielectric



Quiz

Conducting spheres and a long wire:



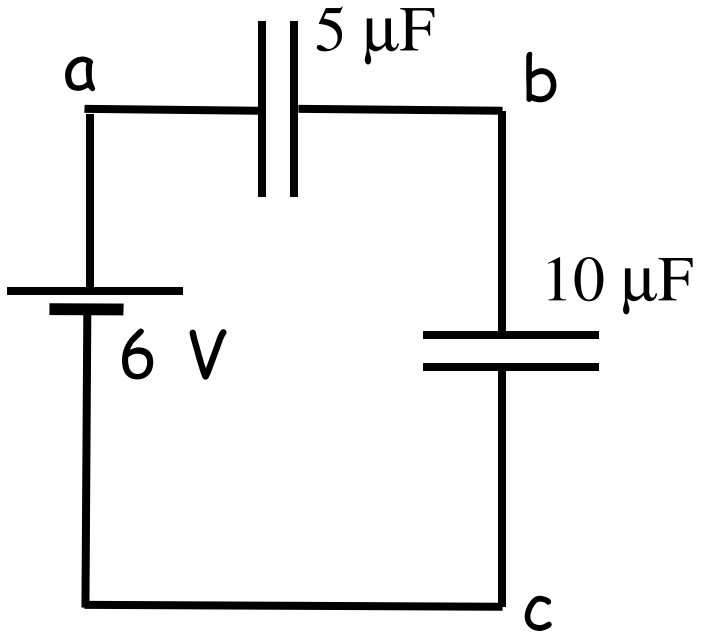
A total charge +12 μC is placed on one sphere. Some of the charge will move to the other sphere until

A) the electric fields outside the spheres are equal
B) the electric potentials on the spheres are equal
C) the electric charges on the spheres are equal
D) all of the above

Extra Quiz (review)

How does the potential difference V_{ab} between a and b compare to the potential difference V_{bc} between b and c?

(The capacitors were initially uncharged before the battery was connected.)



A) $V_{ab} = V_{bc}$
B) $V_{ab} > V_{bc}$
C) $V_{ab} < V_{bc}$