Capacitors

PHY 114-01

Fall 2026

Agenda

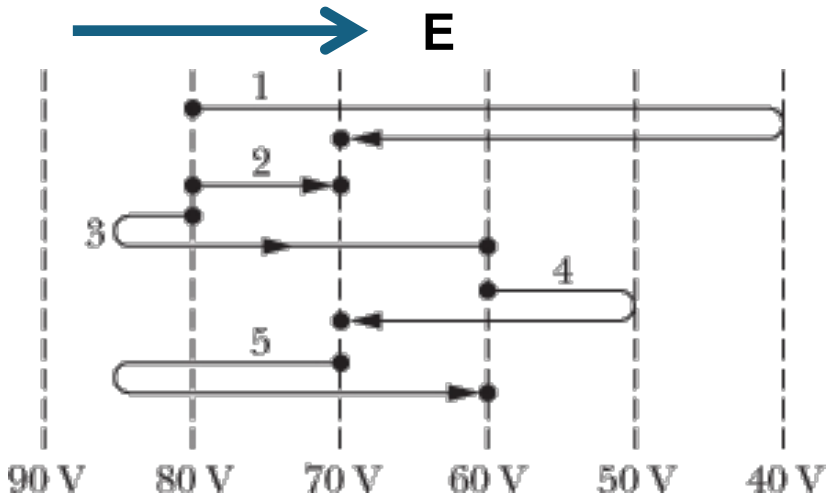
- Last time:
  - Wrap up calculating field and potential
  - Equipotential surfaces

- This time:
  - Capacitors and capacitance

Concept check: Electric potential

The figure shows a family of parallel equipotential surfaces (in cross section) and five paths along which we shall move an **electron** from one surface to another.

What is the direction of the electric field associated with the surfaces?

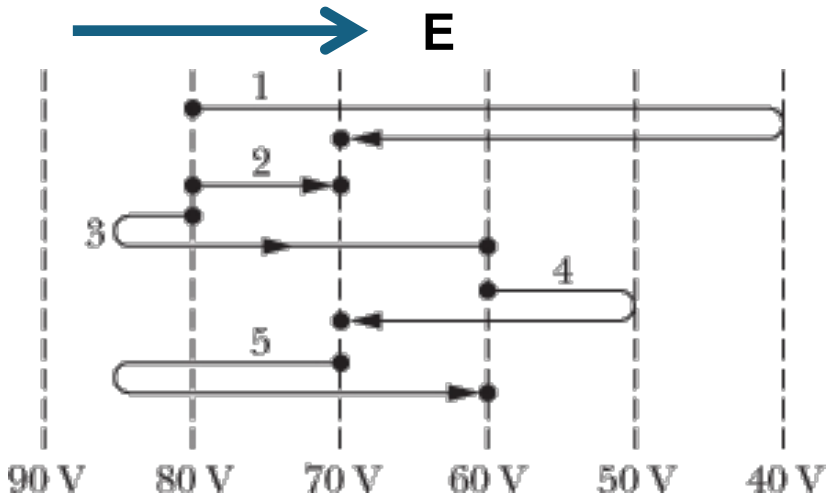


A. Left
B. Right
C. Up
D. Down
E. None of the above

Concept check: Electric potential

The figure shows a family of parallel equipotential surfaces (in cross section) and five paths along which we shall move an **electron** from one surface to another.

For each path, is the work **we do** positive, negative, or zero?



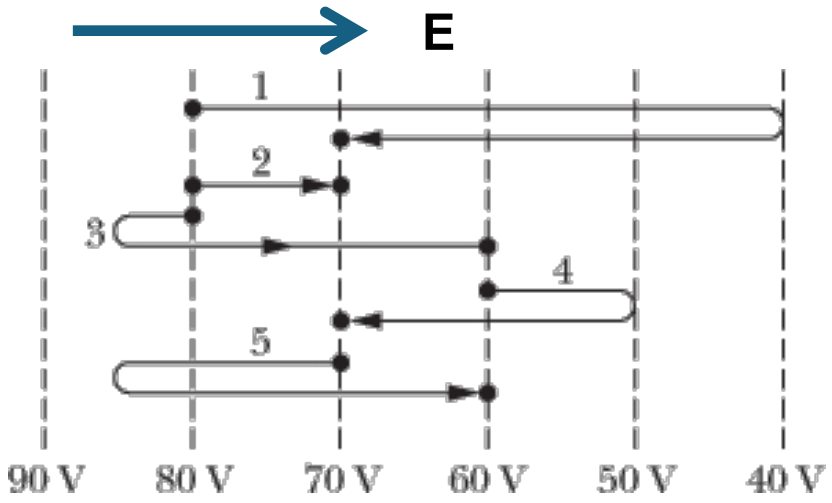
A. Positive
B. Negative
C. Zero

F_{ext} ➔
positive : 1,2,3,5
negative: 4

Concept check: Electric potential

The figure shows a family of parallel equipotential surfaces (in cross section) and five paths along which we shall move an **electron** from one surface to another.

Rank the paths according to the work we do, greatest first.



A. 1 > 3 > 5 > 4 > 2
B. 2 > 4 > 5 > 3 > 1
C. 3 > 1 = 2 = 5 > 4
D. 3 > 1 = 2 = 5 = 4
E. None of the above

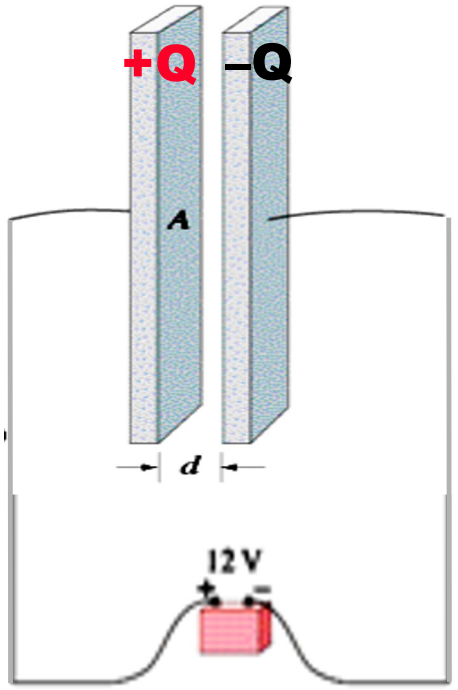
Capacitors

- **device to store charge and energy**
- **simplest type:**
  - ➢ **connect two parallel plates to a battery**
    - **potential will move charges**
    - **plates become charged (Q)**
      - ➢ **the amount of charge moved depends on the voltage (V)**

charge ∝ potential difference

$$Q = C V$$

Q refers to charge on one plate

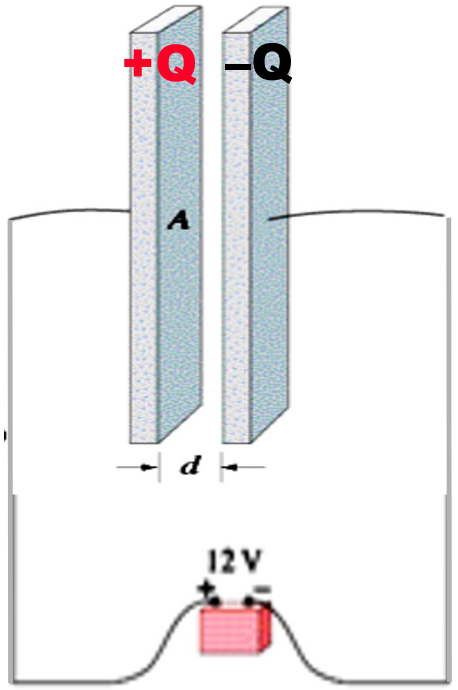


Capacitors

charge $\propto$ potential difference

$$Q = C V$$

- constant C is called ***capacitance***
  - relates how much charge stored for a given voltage
  - C = Q/V, a constant that depends on the *geometry* (area, separation)
  - larger C $\Rightarrow$ larger Q (for fixed V)
  - units: coulomb / volt $\equiv$ Farad (F)

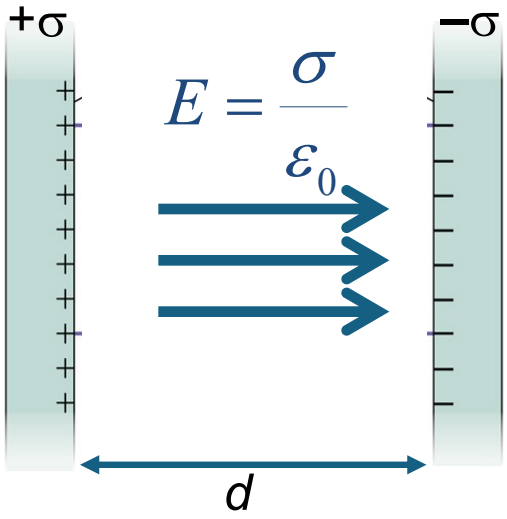


Calculating the Capacitance

Parallel-plate Capacitor

Recall (Ch.23) *E* is uniform inside the plates, so the potential difference is

$$V = Ed = \frac{\sigma d}{\varepsilon_0}$$



Charge on one plate is $Q = \sigma A$,
A = area of the plate

Apply $C = Q/V$, we have

$$C = \frac{Q}{V} = \frac{\sigma A}{\sigma d / \varepsilon_0} = \frac{\varepsilon_0 A}{d}$$

for parallel-plate capacitor, depends on geometries only

d = separation of plates; $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$

How Big Is 1 Farad?

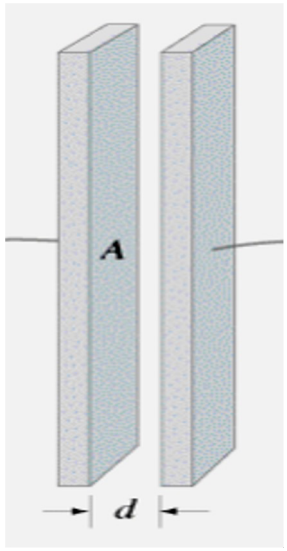
- **unit of capacitance is the Farad: 1 C/V**
  - **choose d = 1 mm**
  - **find the area A for such a capacitor**

$$C = \frac{\varepsilon_0 A}{d}$$

$A = Cd/\varepsilon_0$

$= (1\text{ F})(0.001\text{ m}) / (8.85\times10^{-12})$

$= 1.1 \times 10^8\text{ m}^2$ = **43 sq. miles!**





This capacitor is as big as a city!!!

- **typical capacitances are measured in picoFarads (pF) = 10^{-12} Farad**

ConceptCheck Capacitors

A capacitor is connected across a battery of 3 V, and its capacitance is measured to be C. If it is connected across a battery of 6 V, its capacitance is

A. C ✓
B. 2C
C. ½ C
D. need more information

$$C' = Q'/V' \qquad V' = 2V$$

But $Q' = 2Q$

so $C' = C$ is unchanged. Capacitance depends on device (geometry etc) only

ConceptCheck Capacitors

A capacitor is connected across a battery of 3 V, and its charge is measured to be Q. If it is connected across a battery of 6 V, its charge is

A. **Q**

B. **2Q** ✓

C. **½ Q**

D. **need more information**

Q = C V,

so twice amount of charge

ConceptCheck Capacitors

A parallel-plate capacitor initially has a potential difference of 400 V . It is then disconnected from the charging battery. If the plate spacing is now doubled (without changing Q), what is the new value of the voltage?

A. 100 V
B. 200 V
C. 400 V
D. 800 V ✓
E. 1600 V

$C = Q / V$, or $V = Q / C$
doubling d halves C
halving C doubles V
(holding Q fixed)