



Hilla University Collage

Department of Prosthetics Dental Technology



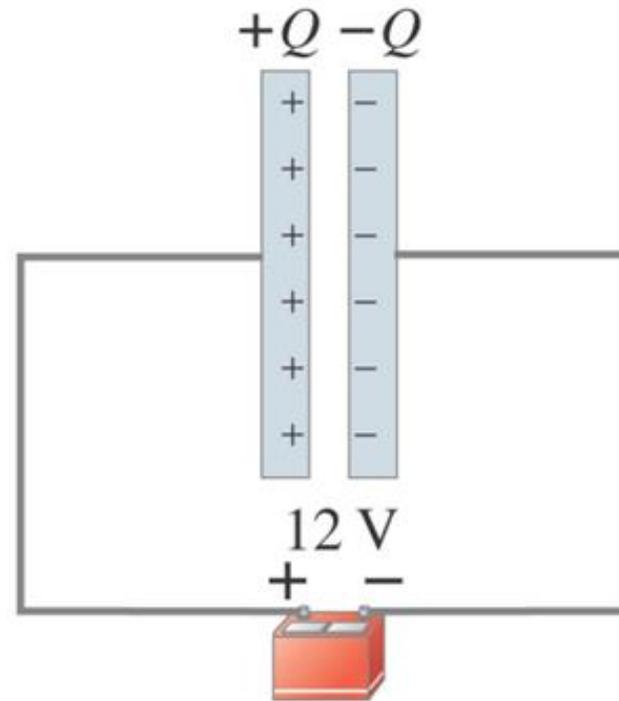
Lecture Three

The capacitor

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The Capacitor

A device which is used to store electrical charge. In its most basic form, composed of two plates separated by a dielectric (insulator).



Parallel-plate capacitor connected to battery

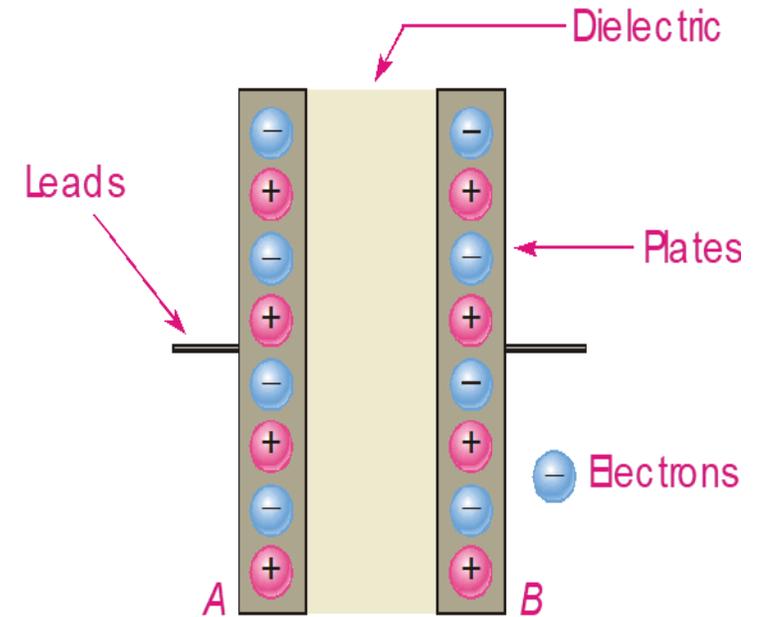


Circuit diagram.

How the capacitor work

The charging process.

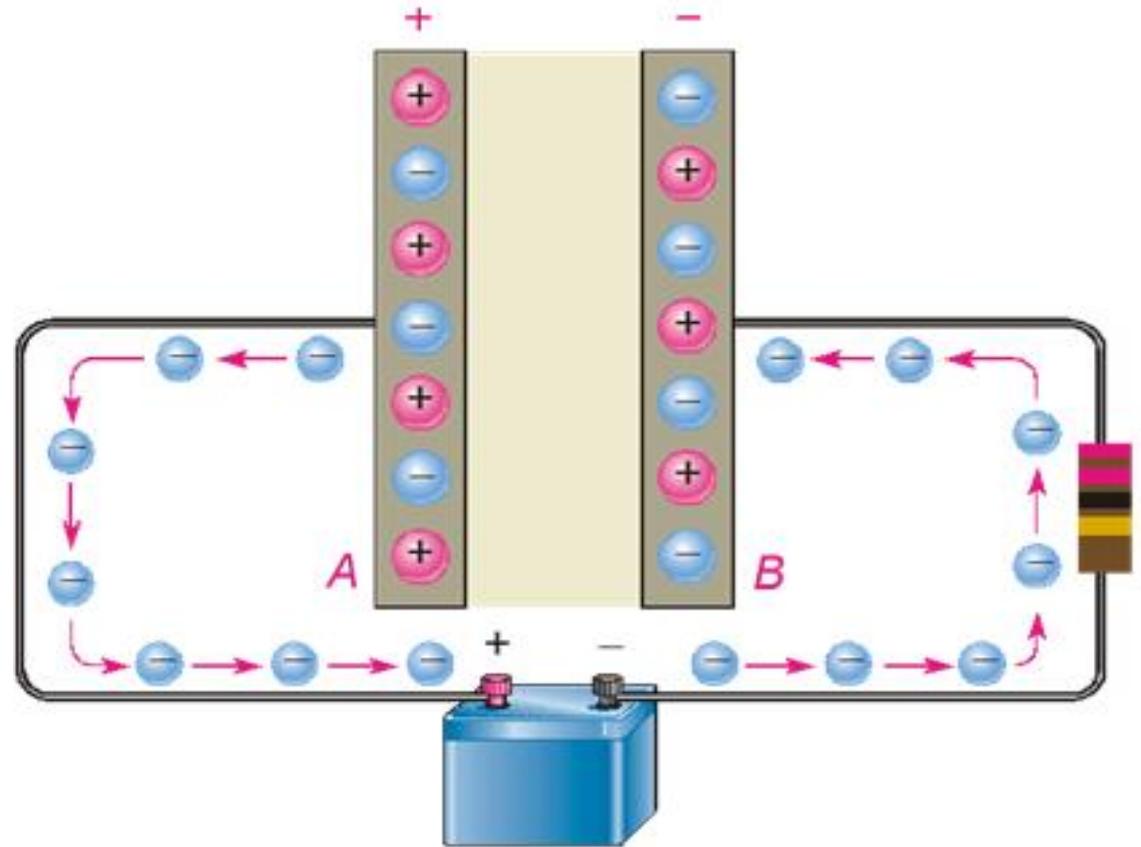
Initially uncharged



- Two parallel metallic plates separated by a dielectric (insulator) material
- Dielectric material is non-conductive
- *Positive* and *Negative* charges collect on separate plates

How the capacitor work

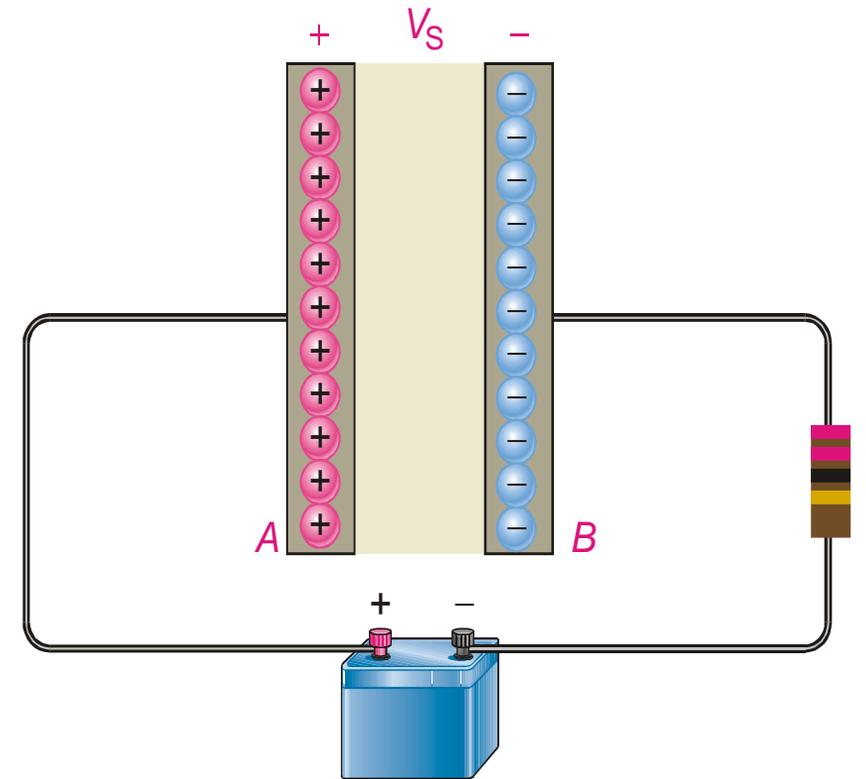
Charging



- Electrons get stuck on one plate. Positive charges get pushed to the other plate.

How the capacitor work

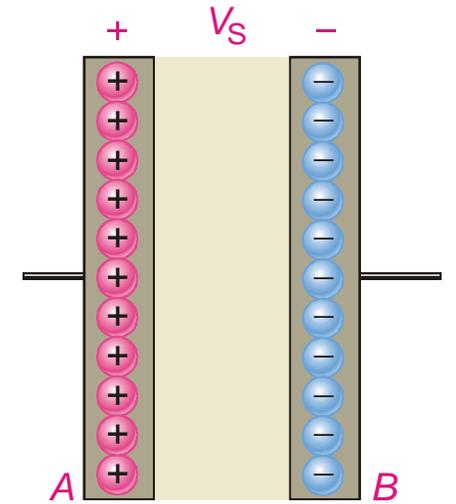
Fully charged



- Two plates are attracted to each other, but the dielectric material keeps them forever apart.
- This creates an *Electric Field*, and the capacitor is storing the charge.

How the capacitor work

Source removed



- A capacitor with stored charge can act as a temporary battery.

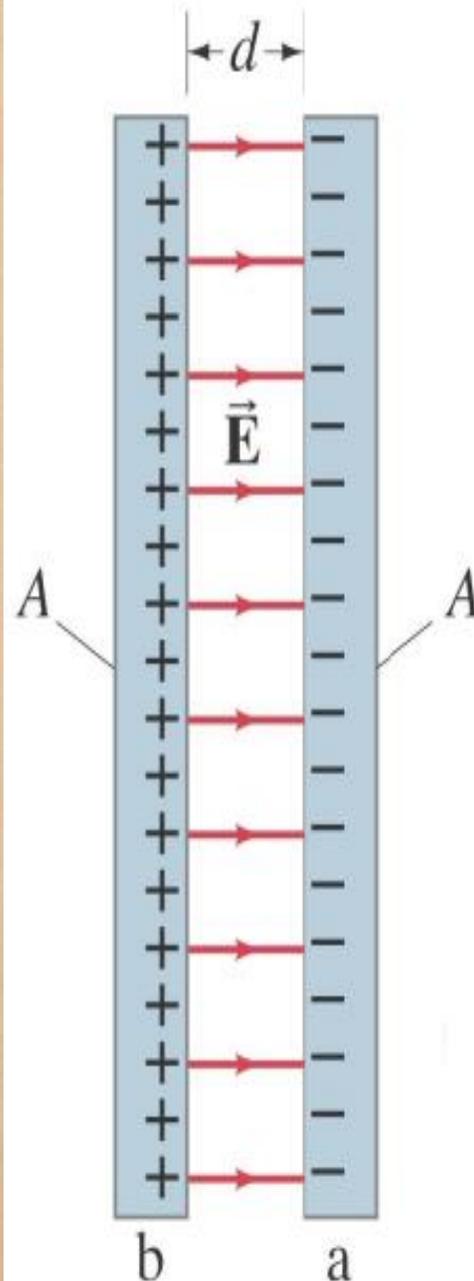
Capacitance

- Measured in Farads $1 \text{ F} = 1 \text{ C/V}$.
- Capacitance is one Farad when one Coulomb is stored on the plates by one Volt.
- Mathematically, capacitance is the ratio of charge to voltage

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

Example If a $22 \mu\text{F}$ capacitor is connected to a 10 V source, the charge is $220 \mu\text{C}$

Determination of Capacitance



- For a parallel-plate capacitor as shown, the field between the plates is.

$$E = Q/\epsilon_0 A.$$

Q: is the charge

ϵ_0 : is the permittivity of the dielectric material between the plates. (8.85×10^{-12} F/m)

A: is the surface area of each plate

- The potential difference:

$$V_{ba} = Ed = Qd/\epsilon_0 A.$$

d: is the distance between the plates

- This gives the capacitance:

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

Capacitors in series

Capacitors in series

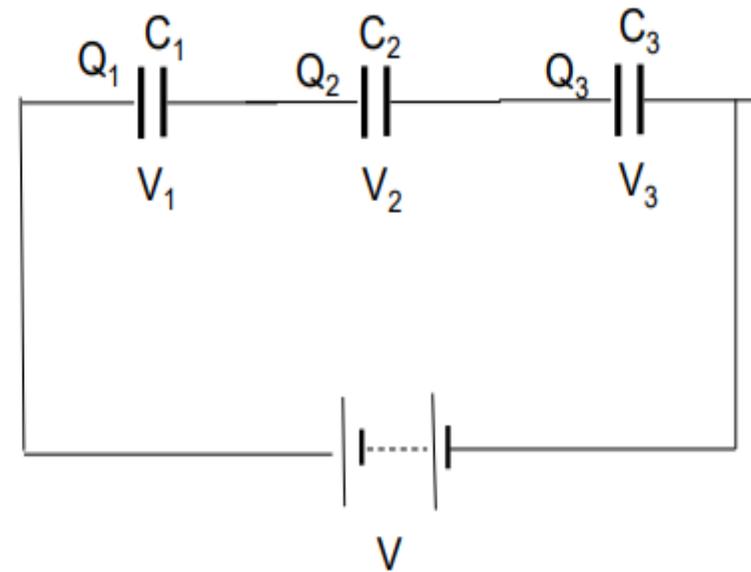
$$V_1 = \frac{Q}{C_1} \quad V_2 = \frac{Q}{C_2} \quad V_3 = \frac{Q}{C_3}$$

adding $V_1 + V_2 + V_3 = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$

i.e. $V = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$

A single capacitor which has the same effect is: $V = \frac{Q}{C}$

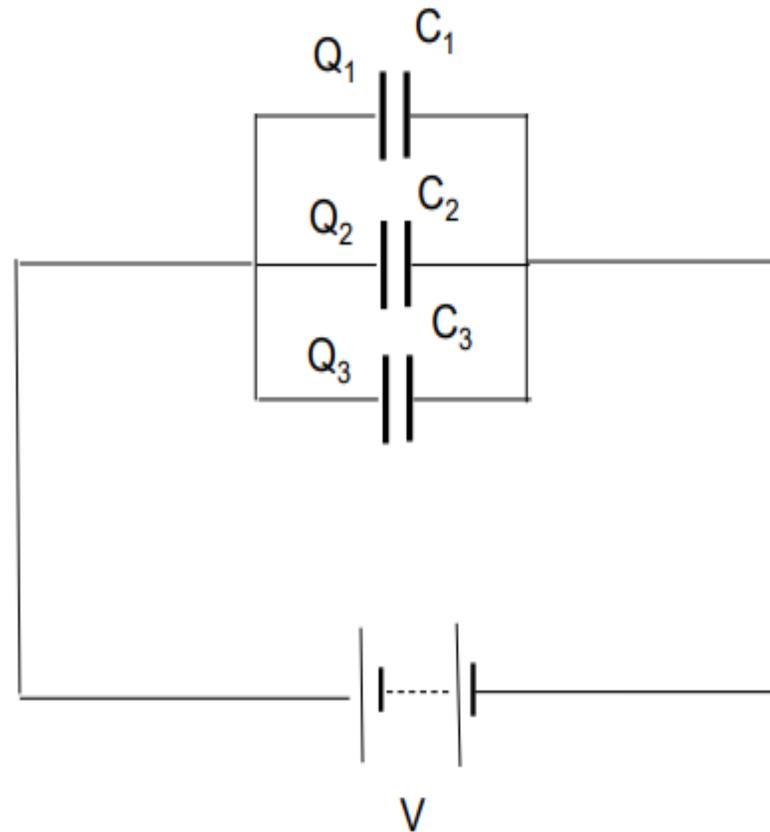
So: $\frac{1}{C} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$



Capacitors in parallel

Capacitors in parallel

The capacitors are in parallel and therefore there is the same p.d. across each



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

$$Q_1 = C_1V \quad Q_2 = C_2V \quad Q_3 = C_3V$$

$$Q_1 + Q_2 + Q_3 = C_1V + C_2V + C_3V$$

$$Q_1 + Q_2 + Q_3 = (C_1 + C_2 + C_3)V$$

A single capacitor which stores as much charge ($Q = Q_1 + Q_2 + Q_3$) is represented by:

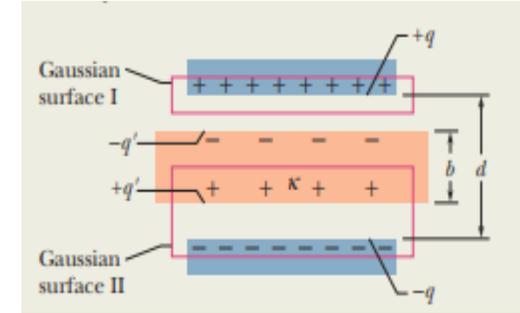
$$Q = CV$$

$$\text{So } C = C_1 + C_2 + C_3$$

It follows that capacitors in parallel have a total capacitance which is equal to the sum of their individual capacitances.

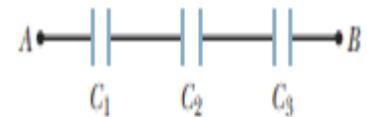
Questions

- Figure shows a parallel-plate capacitor of plate area $A = 115 \text{ cm}^2$, and plate separation $d = 1.24 \text{ cm}$. A potential difference $V_0 = 85.5 \text{ V}$ is applied between the plates by connecting a battery between them.

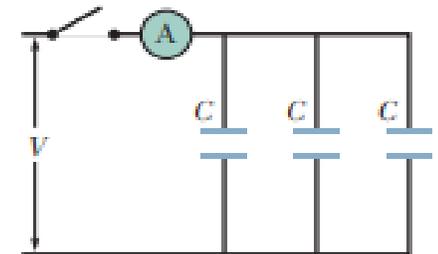


- (a) What is the capacitance C_0 before the dielectric slab is inserted?
 (b) What free charge appears on the plates?

- Fig. $C_1 = 10.0 \mu\text{F}$, $C_2 = 20.0 \mu\text{F}$, and $C_3 = 25.0 \mu\text{F}$. If no capacitor can withstand a potential difference of more than 100 V without failure, what are the magnitude of the maximum potential difference that can exist between points **A** and **B**.



- Each of the uncharged capacitors in Fig. has a capacitance of $25.0 \mu\text{F}$. A potential difference of $V = 4200 \text{ V}$ is established when the switch is closed. How many coulombs of charge then pass through meter A?





THANK YOU FOR LISTENING