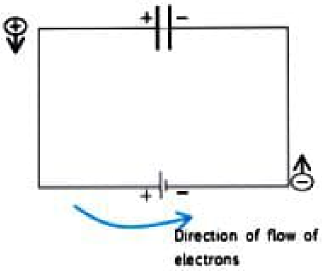
CAPACITORS

- A capacitor is a device which is used to store electric charge
- Basically a capacitor consists of a pair of parallel metal plates separated by an insulator known as **dielectric** between the plates.
- Each plate of a capacitor will store separate type of electric charge.

Mechanism of storing charge in a capacitor or charging a capacitor

When a battery is connected to a capacitor, there is a momentary flow of current after which current stops flowing



- Electrons are drawn from point **A** by the positive terminal of the batt‹
  and are deposited at the action of the negative terminal.
- After a short time, the potential of A will be equal to that of the positive terminal of the battery and potential at **B** equals to that of the negative terminal of the battery
- At this stage, the p.d across the capacitor becomes equal to that of the battery and no current flows. The capacitor is now fully charged

Discharging a capacitor

- When the battery is disconnected and the plates are joined together by a wire, electrons flow back from the negative plate to the positive plate until the positive charge on it is completely neutralized.
- A current thus flows for a short time in the wire in the opposite direction and then stops. At this stage charges on the capacitor plates is zero. The capacitor is fully discharged

Capacitance of a capacitor (C)

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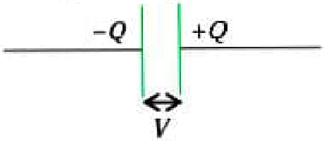


By definition, $C = \frac{\text{Charg e on one plate of capacitor}}{\text{p.d across the capacitor}}$

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

Where Q is the charged is stored in the capacitor plates when connected to p.d V

The SI unit of capacitance is the **Farad** (F)

The **Farad** is the capacitance of a capacitor which stores **one coulomb** of charge when a p.d across the capacitor is **one volt**

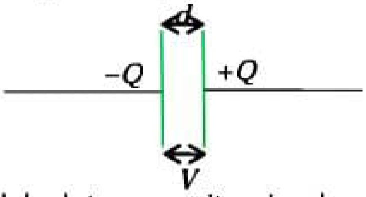
Derived units of capacitance

microfard$(1\mu F)$: $1\mu F = 1\times10^{-6} F$

nonofarad$(1nF)$: $1nF = 1\times10^{-9} F$

picofard$(1pF)$: $1pF = 1\times10^{-12} F$

The capacitance of a parallel plate capacitor



Suppose that when a parallel plate capacitor is charged to a p.d V the charge on each plate is Q

By definition $$C = \frac{Q}{V} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The uniform electric field intensity E between the plates is given by

$$E = \frac{V}{d} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

From Gauss's law, Electric field intensity E is also given by

$$E = \frac{\delta}{\varepsilon}$$

Where δ is the charge density, given by $\delta = \dfrac{Q}{A}$

$$E = \frac{Q}{\varepsilon A} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$\frac{V}{d} = \frac{Q}{\varepsilon A}$$

$$\frac{\varepsilon A}{d} = \frac{Q}{V} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Combine (1) and (4)

$$\boxed{C = \frac{\varepsilon A}{d}}$$

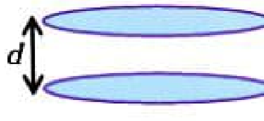
Where ε is the permittivity of the dielectric material

If the space between the plates is vacuum or air $\varepsilon = \varepsilon_0$ such that

$$C_0 = \frac{\varepsilon_0 A}{d}$$

Example: Calculate the capacitance of a pair of parallel circular discs each of diameter 16cm with an air gap of 5mm. assume $\varepsilon_0 = 8.85 \times 10^{-12}\, Fm^{-1}$

Solution



$$A = \pi r^2 = 6.4 \times 10^{-3} \pi\, m^2$$

$$C_0 = \frac{\varepsilon_0 A}{d} = 1.133 \times 10^{-11} F = 11.33\, pF$$

Arrangement of capacitors