PHY-101

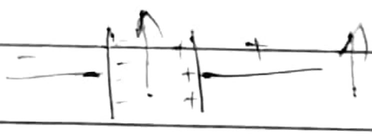
Lecture # 25

(1) Point # 1

⇒ Capacitor:

Device to store charges.

* Capacitance



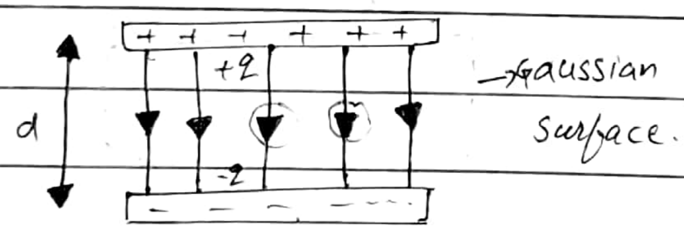
Charge ∝ Potential Difference.

$Q \propto V$

$Q = CV$

$C = Q/V \rightarrow$ (A)

(2) Parallel Plate Capacitor:



Gausses Law

$\phi = \frac{q_{enclosed}}{\varepsilon_0} \rightarrow (1) \quad \phi = \int \vec{E} \cdot d\vec{A} \rightarrow (2)$

From (1) & (2)

$EA = \frac{Q}{\varepsilon_0} \Rightarrow E = \frac{Q}{\varepsilon_0 A}$

$$E = \frac{Q}{\varepsilon_0 A} \quad , \therefore V = \frac{E}{d} \rightarrow (3)$$

put [redacted] E in (3)

$$V = \frac{\frac{Q}{\varepsilon_0 A}}{d}$$

$$= \frac{Q}{\varepsilon_0 A} \times d = \frac{Qd}{\varepsilon_0 A}$$

$$\boxed{V = \frac{Qd}{\varepsilon_0 A}} \rightarrow (4)$$

Now

$$C = \frac{Q}{V} \rightarrow (5)$$

put 'V' in (5)

$$C = \frac{Q}{\frac{Qd}{\varepsilon_0 A}}$$

$$= \frac{Q}{Qd} \times \varepsilon_0 A$$

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

★ Types of capacitor: plane, cylindrical and spherical.

★ capacitance depends upon:

(i) Geometry

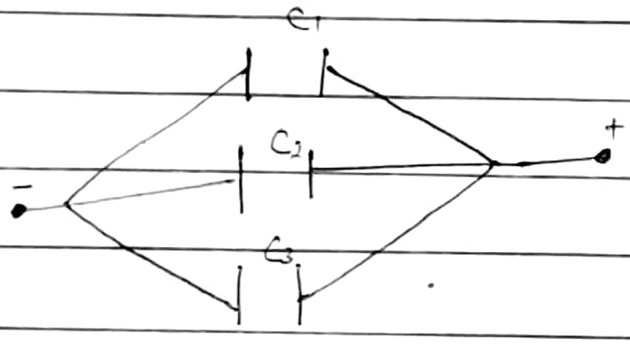
(ii) Size

(iii) Gap b/w plates.

★ Units of capacitances:

$$1 \text{ Farad} = \frac{1 \text{ coulomb}}{1 \text{ volt}}.$$

(3) Capacitor in Parallel:



★ same voltages ★ charge differ

$q_1 = C_1 V, \quad q_2 = C_2 V$

$Q = q_1 + q_2$

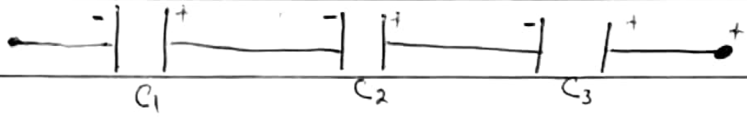
$C_{eq} V = C_1 V + C_2 V$

$C_{eq} = \frac{V (C_1 + C_2)}{V}$

$C_{eq} = C_1 + C_2$

$C_{eq} = \sum C_n$

(4) capacitor in series.



* charges same
* voltage differ.

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

$$V = V_1 + V_2 + V_3$$

$$\frac{q}{C_{eq}} = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$$

$$\frac{q}{C_{eq}} = q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{eq}} = \Sigma \frac{1}{C_n}$$

(5) Energy stored in electric field.

$$dU = Vdq = \frac{q}{C}dq$$

$$U = \int dU = \int_0^Q \frac{q}{C}dq$$

$$U = \frac{Q^2}{2C}$$

$$\therefore Q = CV$$

$$U = \frac{C^{\not{2}}V^2}{2\not{C}}$$

$$U = \frac{CV^2}{2}$$

$$U = \frac{1}{2}CV^2$$

$$\text{Energy density} = \frac{\text{energy}}{\text{Volume}}$$

$$u = \frac{U}{V}$$

$$= \frac{\frac{1}{2}CV^2}{Ad}$$

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

$$= \frac{\frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)V^2}{Ad.}$$

$$= \frac{\varepsilon_0 \not{A} V^2}{2\not{A}d \cdot d}$$

$$= \frac{\varepsilon_0 V^2}{2d^2}$$

$$= \frac{\varepsilon_0}{2}\left(\frac{V}{d}\right)^2$$

$\because E = \frac{V}{d}$

$$= \frac{\varepsilon_0}{2}(E^2)$$

$$u = \frac{\varepsilon_0 E^2}{2} \quad \text{Ans}$$

(6) **Dielectric:**

An insulating material that is placed b/w plates of a capacitor is dielectric.

Coulomb's Law with Dielectric.

$$F = K\frac{q_1 q_2}{r^2} \Rightarrow F = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$F = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1 q_2}{r^2}$$

ε_r = relative permittivity (of medium) (Dielectric constant)

Note:

Electric fiel is weakened by factor $\frac{1}{\varepsilon_r}$

$\varepsilon_r = 1.0003$ For air

$\varepsilon_r \simeq 80$ for pure water.

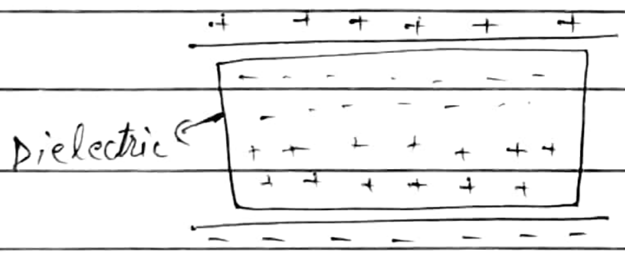
capacitance If there is No dielectric

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

If there is dielectric b/w plates

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

★ Dielectric Polarization.



★ Electric current.

$$i = \frac{dq}{dt}$$

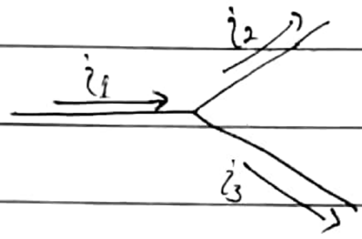
$$1\text{ ampere} = \frac{1\text{ coulomb}}{1\text{ second}} = 1\text{ volt}$$

$$1A = \frac{1C}{1se} = 1V$$

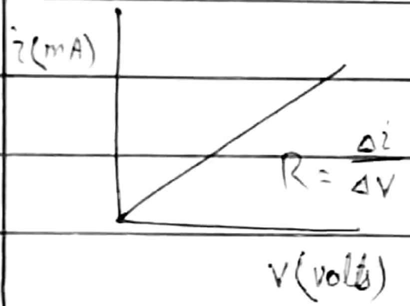
کیا کرنٹ conserve رہتا ہے؟

Law of conservation of current.

$i_1 = i_2 + i_3$



★ OHM'S Law



$V = iR$

The End