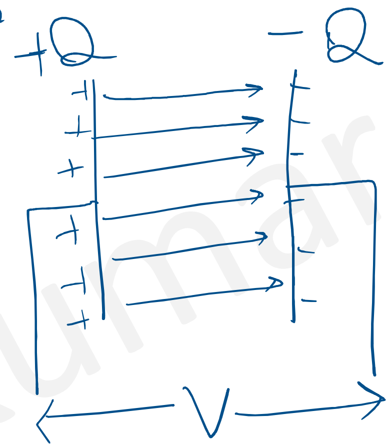
A capacitor is a device that holds charges across a potential V. Its simplest form is two parallel plates separated by an insulating gap



charge stored in a capacitor of capacitance $C = \frac{Q}{V}$

i.e $\boxed{Q = CV}$ $\quad Q \propto V$

where V = P.D. between plates

C depends on the configuration of the capacitor i.e its size, area of plate, separation between plates & dielectric (non-conducting) material between plates

Capacitance is a scalar quantity with dimension

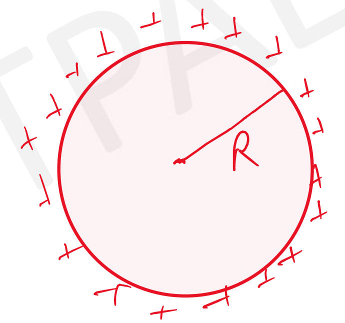
$$C = \frac{Q}{V} = \frac{Q^2}{W} = \frac{A^2T^2}{M^1L^2T^{-2}} = [M^{-1}L^{-2}T^4A^2]$$

Unit = farad

$$1 \text{ farad} = 1F = \frac{1C}{1V} = \frac{1 \text{ coulomb}}{1 \text{ volt}}$$

The capacitance of a spherical conductor

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{R} \Rightarrow \boxed{C = \frac{Q}{V} = 4\pi\epsilon_0 R}$$



if conductor is placed in a medium

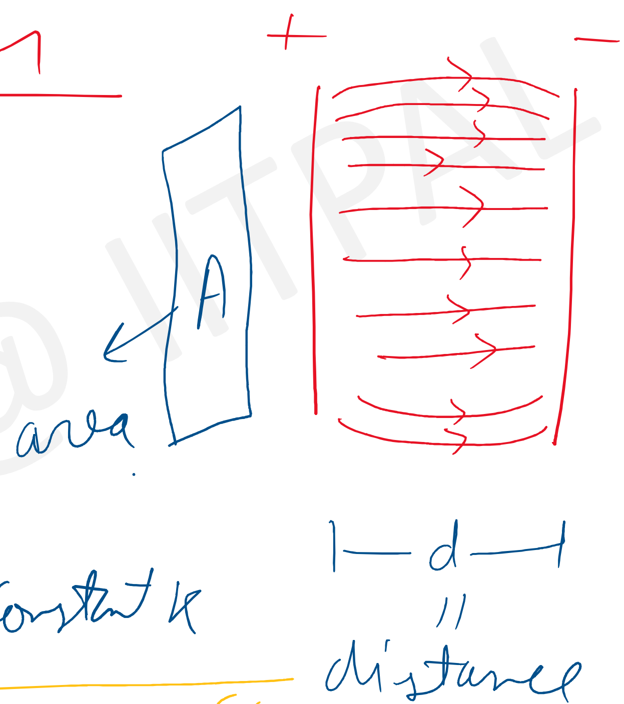
$$C_{medium} = 4\pi\epsilon_0 K R$$

K = dielectric constant

Parallel plate capacitor

(i)

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



if medium between plate is filled with a material of dielectric constant K

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

(ii) Force between the plates

$$F = \frac{1}{2}\epsilon_0 A E^2$$

Force per unit area = F/A
Energy density = u
electrostatic pressure = p

$$\Rightarrow \frac{F}{A} = \frac{1}{2}\epsilon_0 E^2 = u = p$$

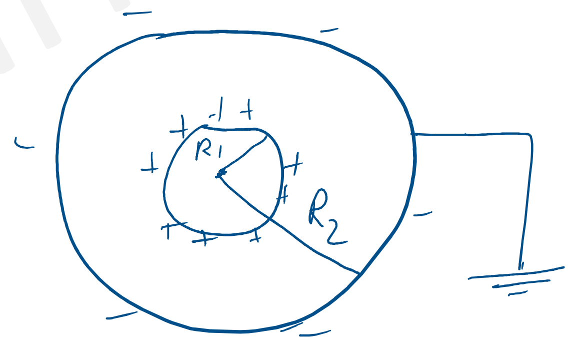
E = electric field
K = dielectric constant

Energy stored in a "charged Conductor"/"Capacitor"

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

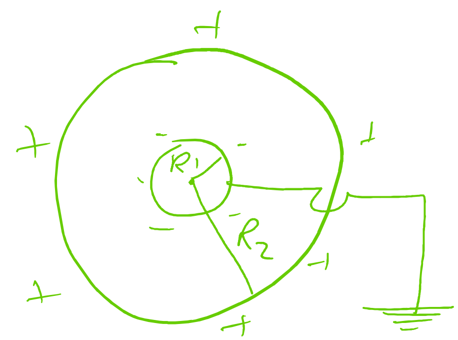
Spherical capacitor

(i) $C = 4\pi\epsilon_0 \dfrac{R_1R_2}{R_2-R_1}$



(ii) when inner sphere is earthed

$$C = 4\pi\epsilon_0\frac{R_1R_2}{R_2-R_1} + 4\pi\epsilon_0 R_2 = \frac{4\pi\epsilon_0 R_2^2}{R_2-R_1}$$

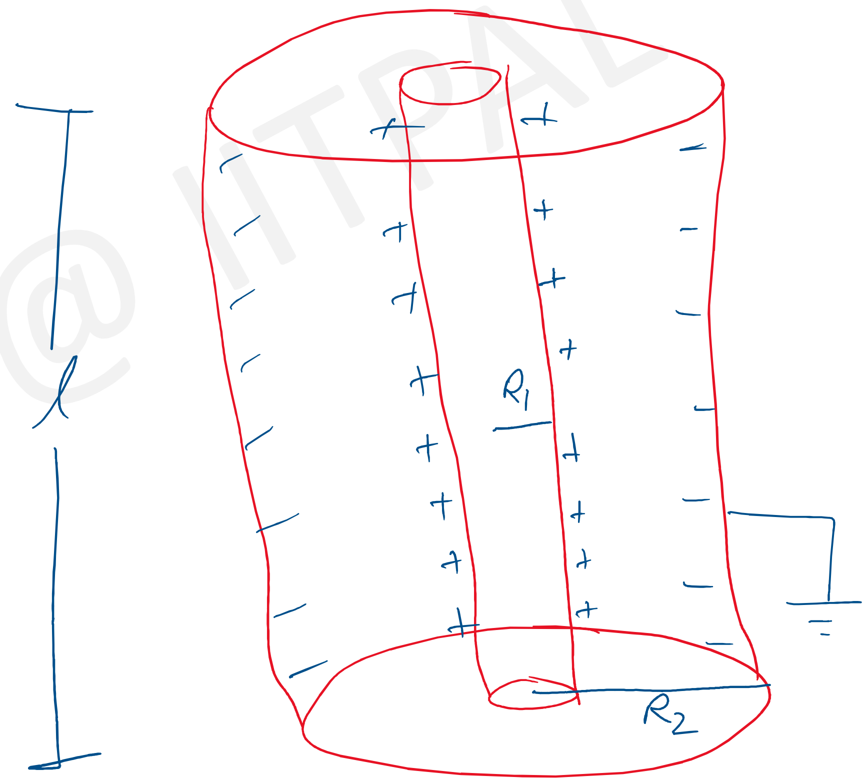


Cylindrical capacitor

$$C = \frac{2\pi \epsilon_0 l}{\log_e\left(\frac{R_2}{R_1}\right)}$$

in presence of medium b/w plates

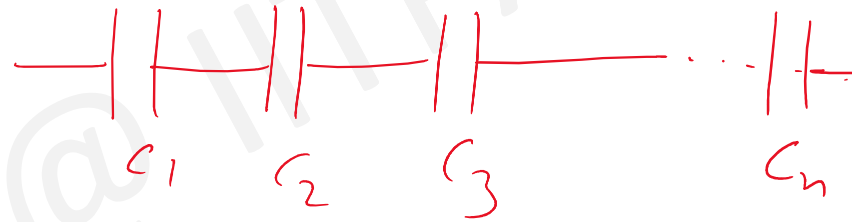
$$C = \frac{2\pi \epsilon_0 K l}{\log_e\left(\frac{R_2}{R_1}\right)}$$



Combination of Capacitors

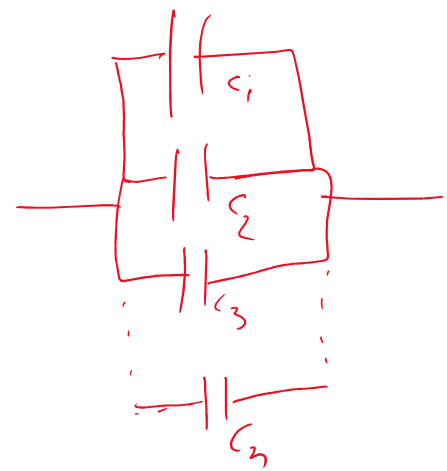
- Capacitor in series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \frac{1}{C_n}$$



- Capacitor in parallel

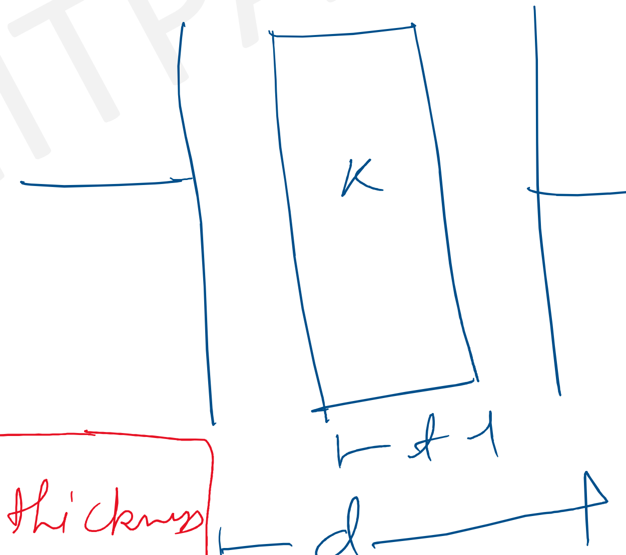
$$C = C_1 + C_2 + C_3 + C_4 \cdots C_n$$



Capacity of Different configuration

(i) partially filled with dielectric

$$C = \frac{\epsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$$



(ii) partially filled with conducting slab of thickness t

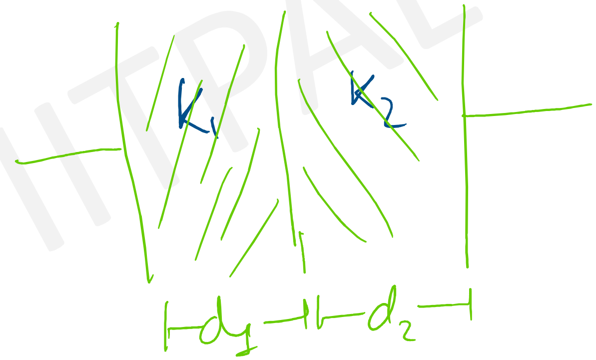
$$C = \frac{\epsilon_0 A}{(d-t)\left(1 - \frac{1}{\infty}\right)} = \frac{\epsilon_0 A}{d-t}$$

$\because K = \infty$ for conductor

Distance & Area division by dielectric

- Distance division

$$C = \epsilon_0 A \left[\frac{K_1 K_2}{d_1 K_2 + d_2 K_1} \right]$$



- Area division

$$C = \frac{\epsilon_0}{d} \left(K_1 A_1 + K_2 A_2 \right)$$