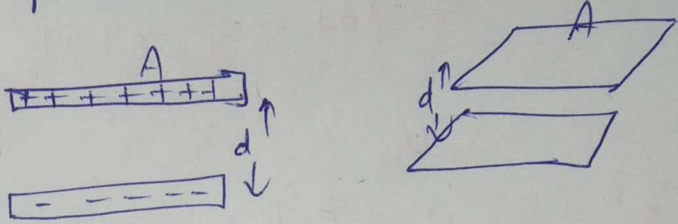
Lecture

① parallel plate capacitor:-

we have two plate of same dimension with +ve & -ve charge and arrange in parallel manner.



Let area of plate be A and seperation b/w them be d.

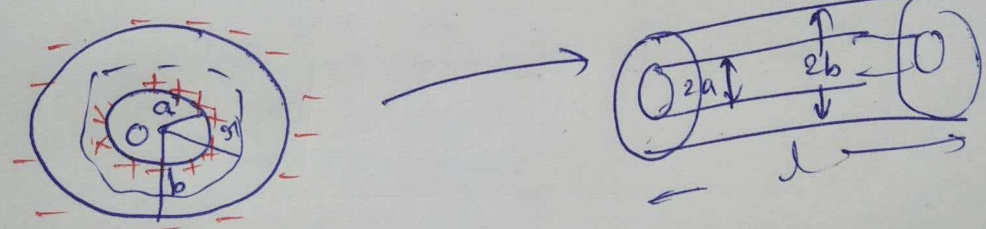
then $C = \frac{\varepsilon_0 A}{d}$

ε_0 = permittivity of vaccum.

unit of capacitance = FARAD

Also $C = \frac{Q}{V}$ = $\frac{\text{Coulomb}}{\text{Volt}}$

② Cylindical Capacitor:-



Let radius of inner surface be a and outer surface be b.

Let λ is charge per unit length and l is length of cylinder

Let us consider a Gaussian surface of radius r.

then $\text{flux} = \frac{q_{enclosed}}{\varepsilon_0}$

$$2\pi r l E = \frac{\lambda l}{\varepsilon_0}$$

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$$

Now potential diff. $V = V(a) - V(b)$

$$= -\int_b^a \vec{E}\cdot d\vec{r}$$

$$= \frac{\lambda}{2\pi\varepsilon_0}\int_a^b \frac{dr}{r}$$

$$V = \frac{\lambda}{2\pi\varepsilon_0}\ln\left(\frac{b}{a}\right)$$

If length is l then

$$\lambda = \frac{Q}{L}$$

$$\therefore \quad V = \frac{Q}{2\pi\varepsilon L}\ln\left(\frac{b}{a}\right)$$

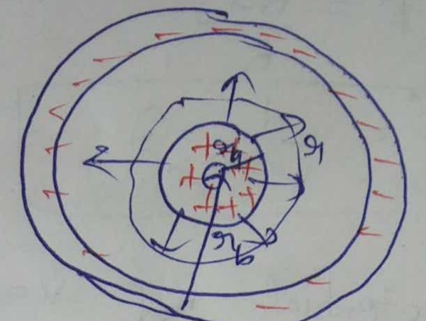
$$C = \frac{Q}{V}$$

$$\Rightarrow C = \frac{2\pi\varepsilon_0 l}{\ln(b/a)}$$ #

Capacitance of cylindrical sur

③ Spherical capacitor :-

Let radius of inner & outer sphere be r_a & r_b resp.



Electric flux through r radius sphere

$$= 4\pi r^2 E$$

$$\Rightarrow \quad 4\pi r^2 E = \frac{Q}{\epsilon_0} \quad \text{(Gauss law)}$$

$$\boxed{\vec{E} = \frac{Q}{4\pi\epsilon_0 r^2}\hat{r}}$$

Now potential difference

$$V = -\int_{r_b}^{r_a} \vec{E}\, d\vec{r}$$

$$= \int_{r_a}^{r_b} \frac{Q}{4\pi\epsilon_0 r^2} dr$$

$$\boxed{V = \frac{Q}{4\pi\epsilon_0}\left(\frac{1}{r_a} - \frac{1}{r_b}\right)}$$

Now capacitance

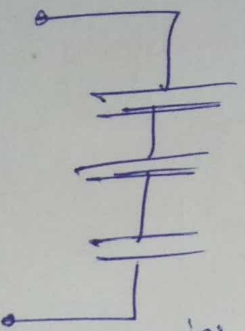
$$C = \frac{Q}{V}$$

$$\boxed{C = \frac{4\pi\epsilon_0 (r_a r_b)}{(r_b - r_a)}}$$

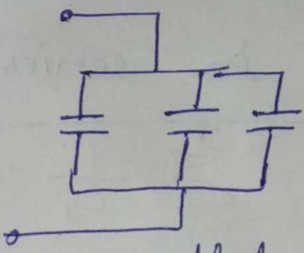
limit $r_b \to \infty$

$$\boxed{C = 4\pi\epsilon_0 r_a}$$ of single sphere.

Capacitors connected in series & parallel :—

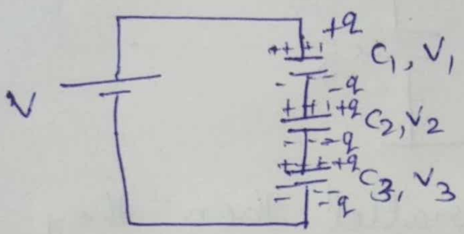


series



parallel

(a) Series :—



$$V = V_1 + V_2 + V_3$$

∵ capacitors are in series then charges remain same on each capacitor

Let charge supplied = q
each of capacitor has +q charge

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

$$V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$$

$$\frac{V}{q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

If total capacitance of circuit be C

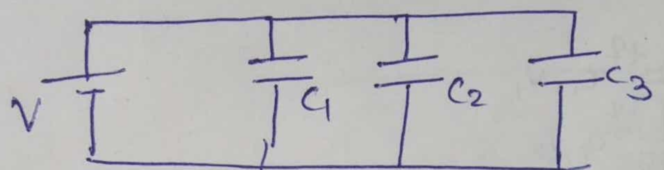
then $C = \frac{q}{V}$

$$\Rightarrow \boxed{\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

for n capacitors in series :-

$$\boxed{\frac{1}{C} = \sum_{i=1}^{n} \frac{1}{C_i}}$$

(b) Capacitance in parallel:-



∵ all capacitors are in parallel then they have same voltage and have different charges.

Let q be the total charge given by battery and q_1, q_2, q_3 be the charges stored in capacitors C_1, C_2, C_3 resp.

then $q = q_1 + q_2 + q_3$

$q_1 = C_1V$, $q_2 = C_2V$, $q_3 = C_3V$

$\therefore q = C_1V + C_2V + C_3V$

$$\frac{q}{V} = C_1 + C_2 + C_3$$

$$\boxed{C = C_1 + C_2 + C_3}$$

for n capacitors in parallel then

$$\boxed{C = \sum_{i=1}^{n} C_i}$$