Capacitor

Capacitance of a Conductor $C = q/V$

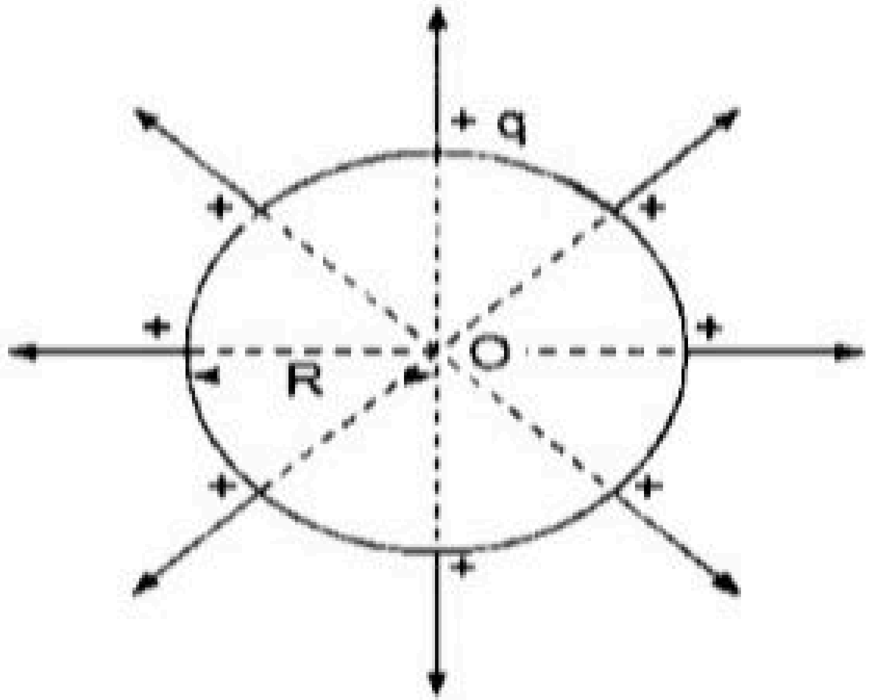
Unit of Capacitance is *'coulomb/volt'* **or** *'Farad'*

(Capacity of an Isolated Spherical Conductor)

$$C = \frac{q}{V} = \frac{q}{(q/4\pi\varepsilon_0 KR)}$$

$$\therefore \quad C = 4\pi\varepsilon_0 KR$$

if $K = 1$ $\boxed{C_0 = 4\pi\varepsilon_0 R}$



(Potential Energy of a charged Conductor)

$$\boxed{U = \frac{1}{2}\, qV = \frac{1}{2}\, CV^2 = \frac{1}{2}\,\frac{q^2}{C}}\ \text{Joule}$$

(Energy Density) $\boxed{u = \frac{U}{V_{olume}} = \frac{1}{2}\,\varepsilon_0 E^2}$ Joule/meter^3

Capacitance of a Parallel plate Capacitor $C_0 = \frac{K\varepsilon_0 A}{d}$

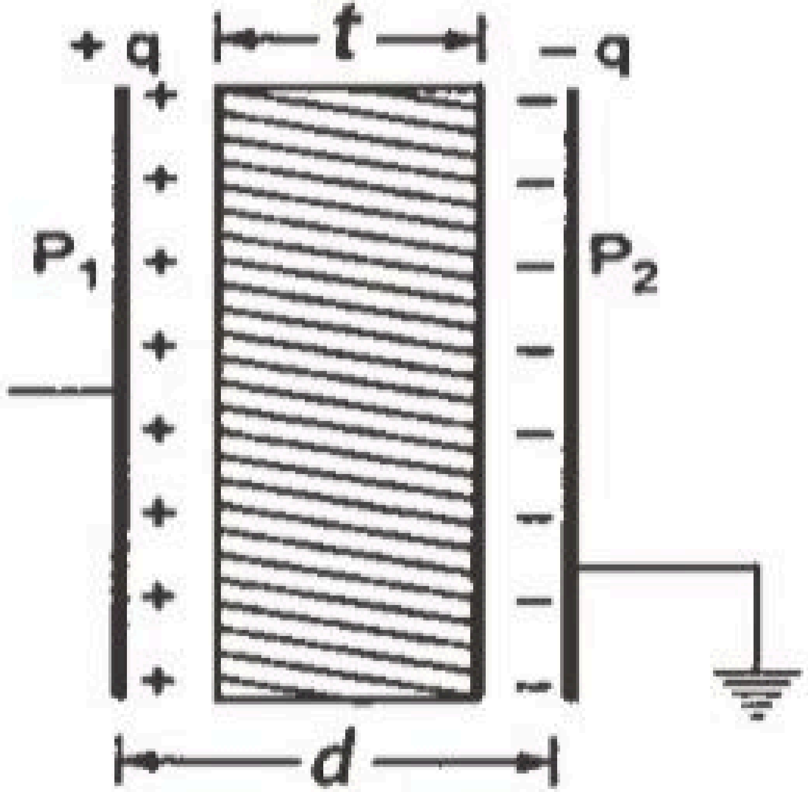
Capacitance of a Parallel-Plate Capacitor depends on :-

1. Area of plates **'A'** $C \propto A$
2. Distance between the plates 'd' $C \propto 1/d$
3. Medium between the plates $C \propto K$

When medium is air $K=1,\ C_0 = \frac{\varepsilon_0 A}{d}$

Capacity of Parallel Plate Capacitor Partially filled with Dielectric Substance

$$C = \frac{\varepsilon_0 A}{\left[(d-t) + \frac{t}{K}\right]}$$



Special Conditions :-

1. If Capacitor is completely filled with dielectric, or ($t = d$)

then Capacitance $C = \dfrac{\varepsilon_0 A}{\left[(d - d) + \dfrac{d}{K}\right]} = \dfrac{K\varepsilon_0 A}{d}$ Farad

2. If Capacitor is containing air only, or ($t = 0$)

then Capacitance $C = \dfrac{\varepsilon_0 A}{\left[(d - 0) + \dfrac{0}{K}\right]} = \dfrac{\varepsilon_0 A}{d}$ Farad

3. If metal plate of thickness 't' is placed between plates ($K = \infty$)

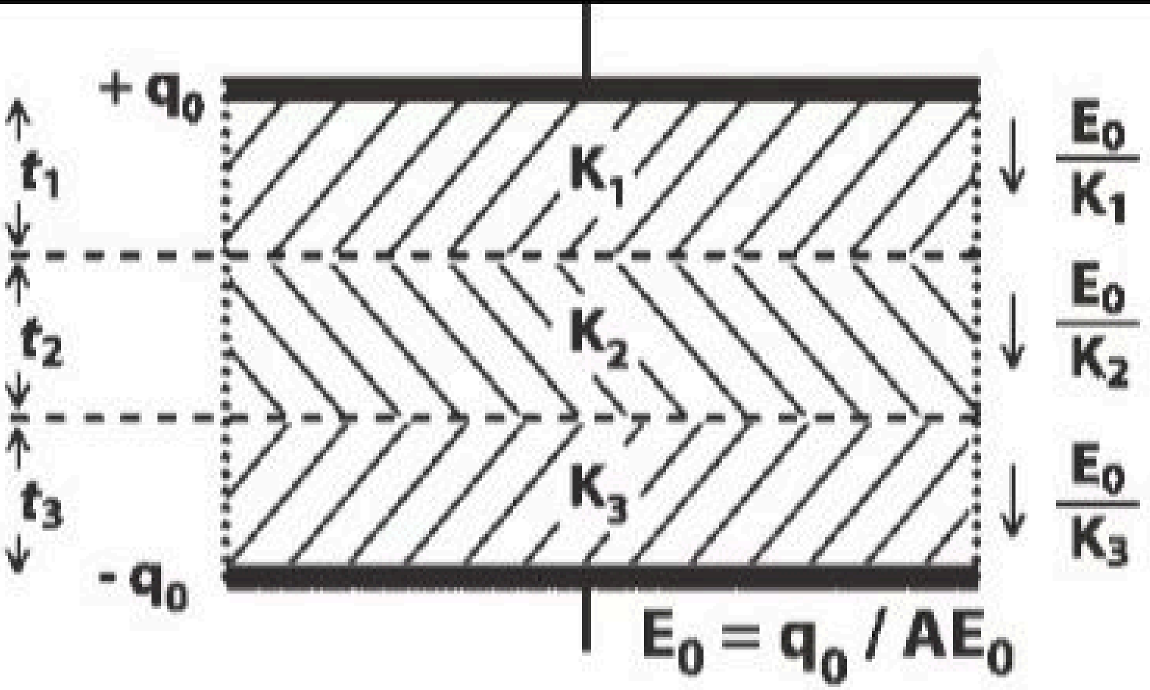
then Capacitance $C = \dfrac{\varepsilon_0 A}{\left[(d - t) + \dfrac{t}{\infty}\right]} = \dfrac{\varepsilon_0 A}{(d - t)}$ Farad

4. if $K_1, K_2, K_3, \ldots, K_n$

Dielectrics is placed between plates whose thickness are

$t_1\ , t_2\ , t_3, \ldots, t_n$

then :-

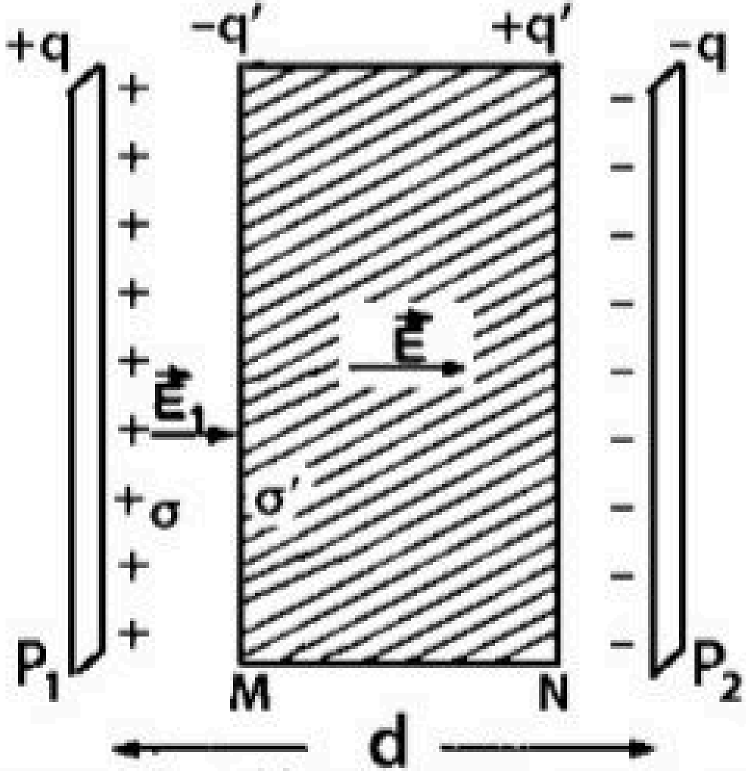


$$C = \frac{\varepsilon_0 A}{\left[d - (t_1 + t_2 + t_3 + \ldots + t_n) + \frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3} + \ldots + \frac{t_n}{K_n}\right]}$$

Magnitude of induced charge on Dielectric :-

$$q' = q\left(1 - \frac{1}{K}\right)$$

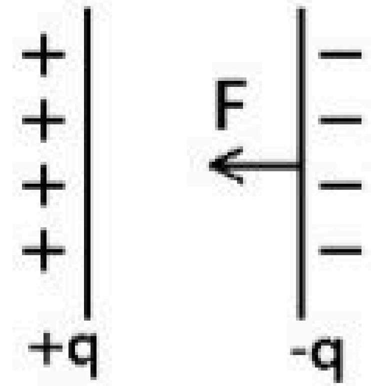
$$\sigma' = \sigma\left(1 - \frac{1}{K}\right)$$



Parallel plate capacitor attract with force :-

$$\boxed{F = \frac{q^2}{2A\varepsilon_0}} \quad \textit{or} \quad \boxed{\frac{F}{A} = \frac{\sigma^2}{2\varepsilon_0}}$$

(Electrostatic stress)



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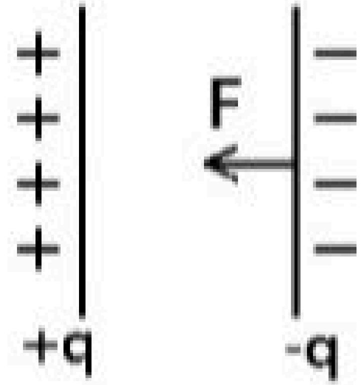
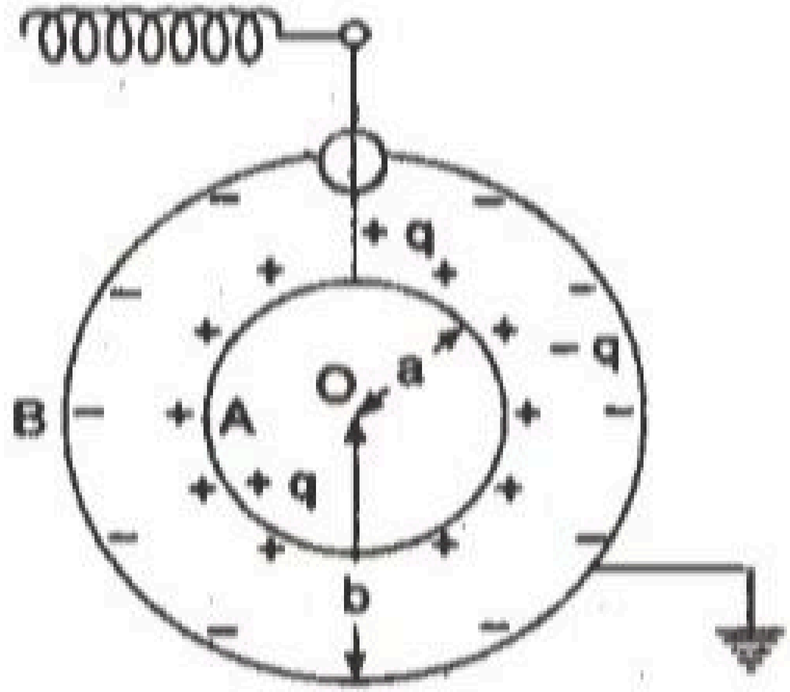


(Capacitance of Spherical Capacitor)

$$C = 4\pi\varepsilon_0 K\left(\frac{ab}{b-a}\right)$$

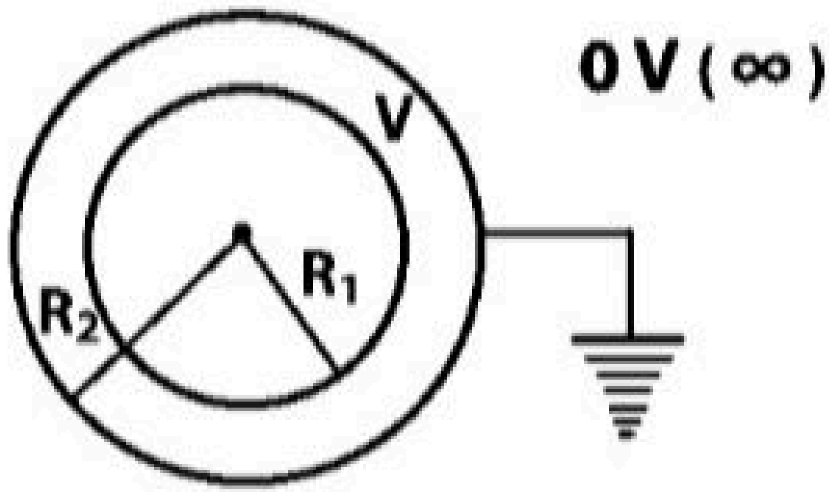
if $K = 1$ $\boxed{C_0 = 4\pi\varepsilon_0\left(\frac{ab}{b-a}\right)}$



Capacitance of spherical capacitor under different earthing condition :-

1) no electric field between outer plate and ∞

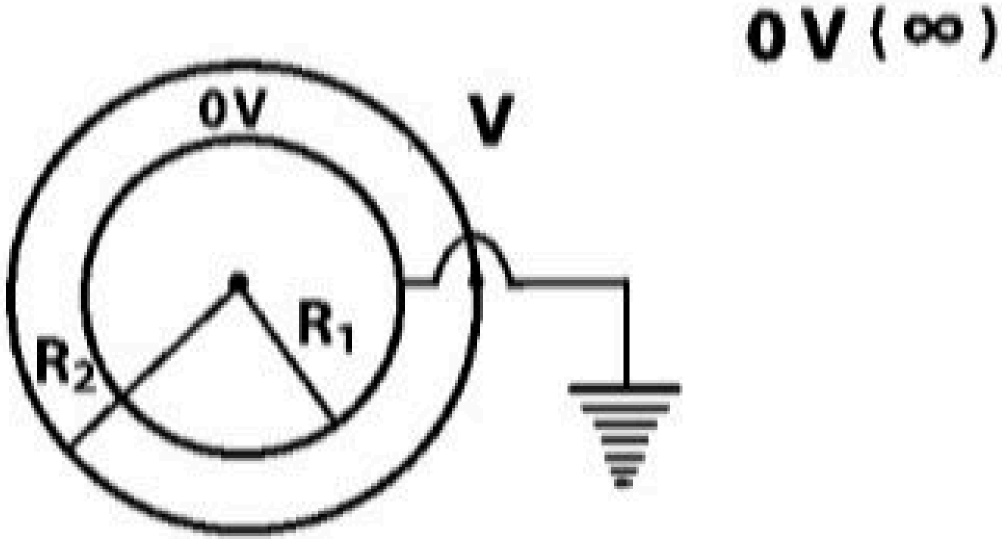
$$\boxed{C = \frac{4\pi\varepsilon_0 R_2 R_1}{R_2 - R_1}}$$



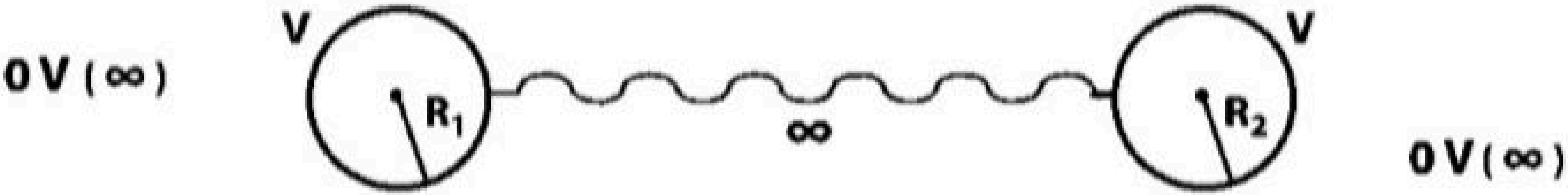
2) Two capacitors present between inner and outer and Infinity (In Parallel) with Potential Difference

$$C = \frac{4\pi\varepsilon_0 R_2 R_1}{R_2 - R_1} + 4\pi\varepsilon_0 R_2$$

$$\boxed{C = \frac{4\pi\varepsilon_0 R_2^{\,2}}{R_2 - R_1}}$$



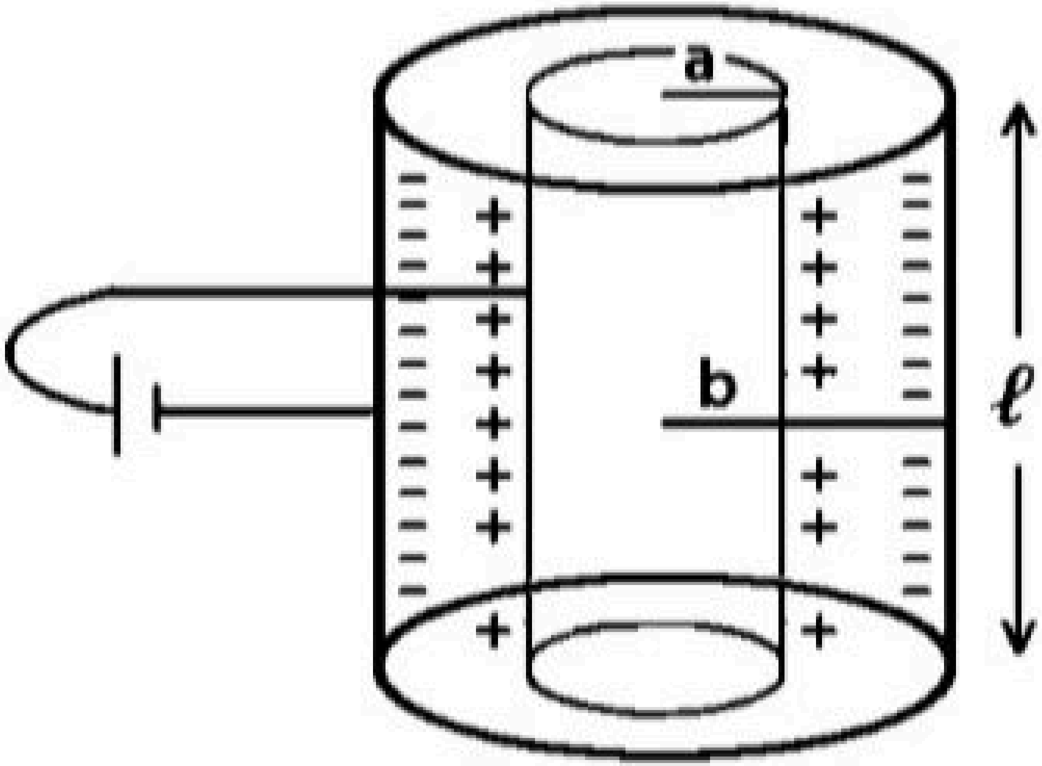
3) Two capacitors joined in paralel (Same P. D. b / w V and ∞)



$$\boxed{C = 4\pi\varepsilon_0 R_1 + 4\pi\varepsilon_0 R_2}$$

Cylindrical capacitor

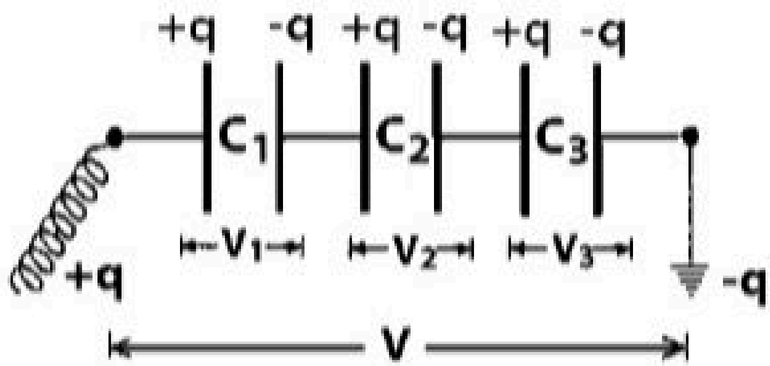
$$C = \frac{2\pi\varepsilon_0 l}{\ln(b/a)}$$



Capacitor connected in Series.

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

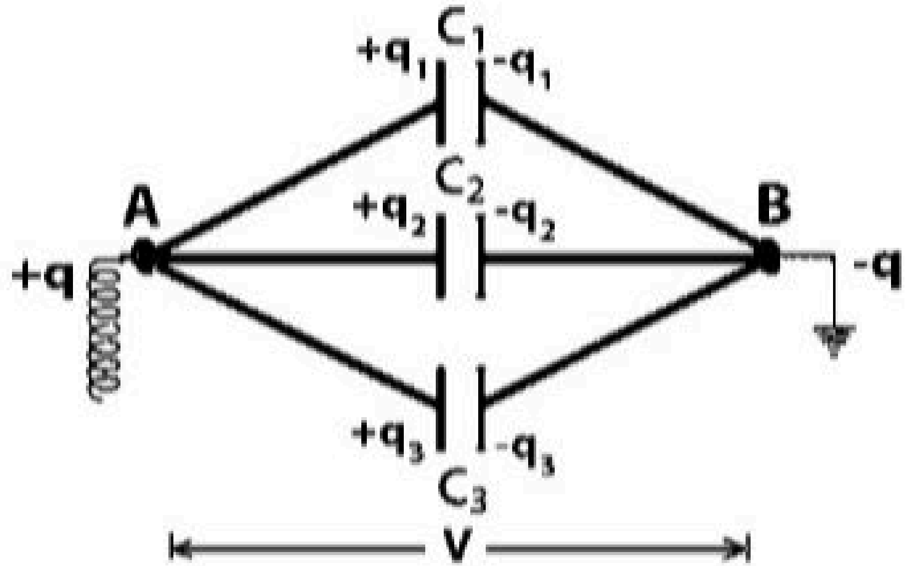
$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$



Capacitor connected in Parallel

$$q_1 = C_1 V$$
$$q_2 = C_2 V$$
$$q_3 = C_3 V$$

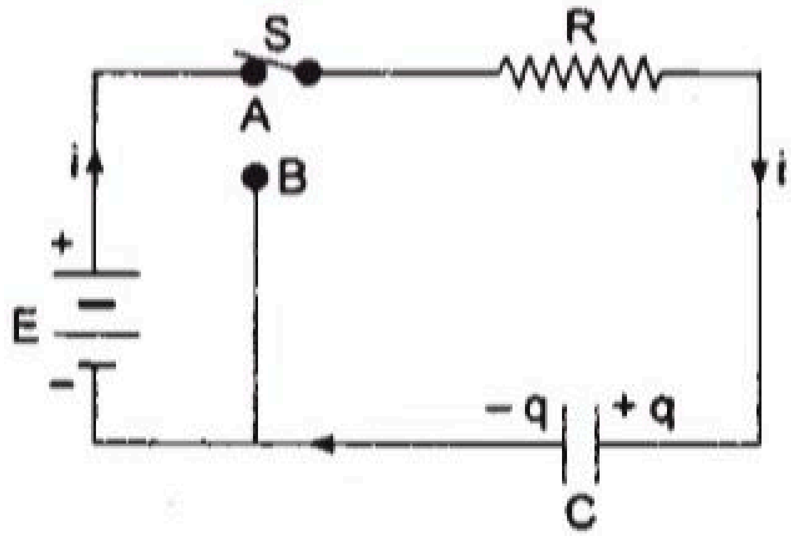
$$C = C_1 + C_2 + C_3$$



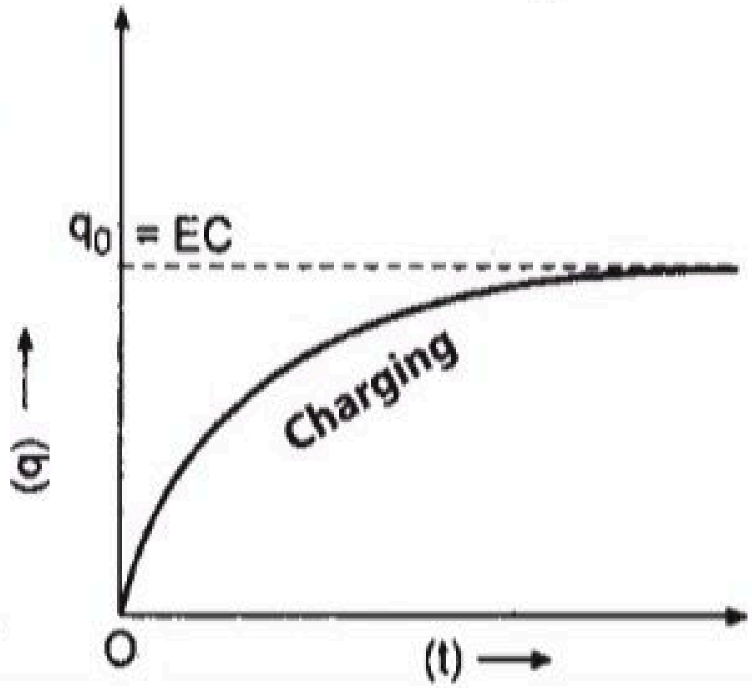
(Charging of a Capacitor through Resistance)

$q_0 = EC$ Maximum Charge

CR is the time constant of circuit



$$\boxed{q = q_0 \left(1 - e^{-t/CR}\right)}$$

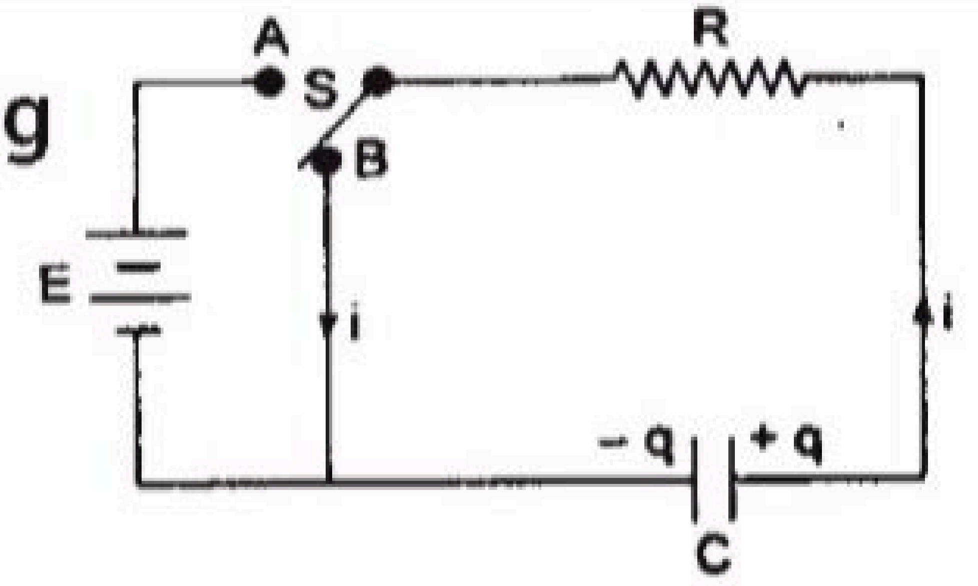


Charging current of circuit

$$i = \frac{dq}{dt} = \left(\frac{q_0}{CR}\right) e^{-t/CR}$$

$$\boxed{i = i_0 e^{-t/CR}} \quad i_0 = \frac{q_0}{CR}$$

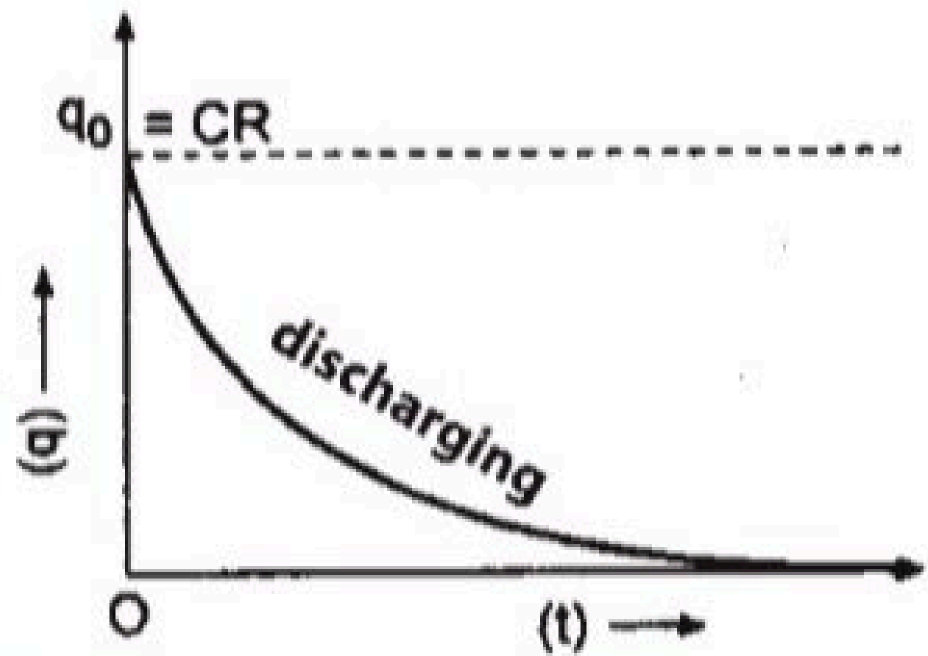
Discharging of capacitor using Resistor



$$\boxed{q = q_0 e^{-t/CR}}$$

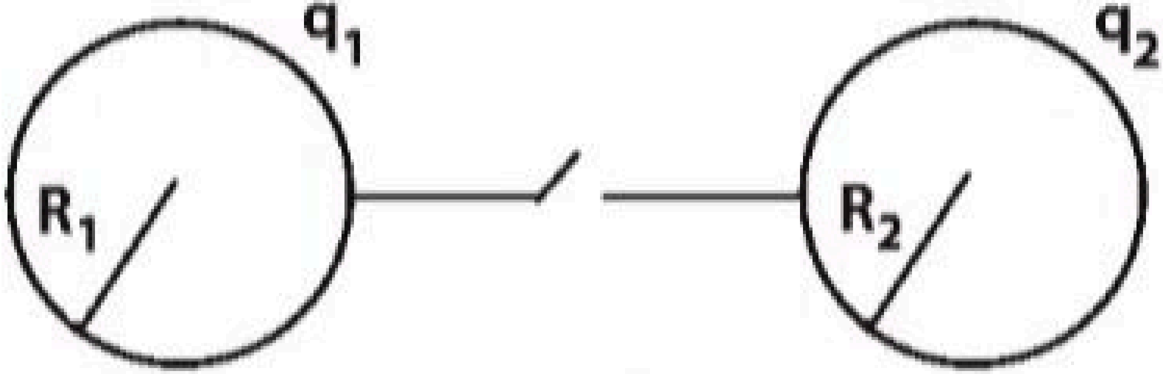
$$i = \frac{dq}{dt} = -q_0 \left(\frac{1}{CR}\right) e^{-t/CR}$$

$$\boxed{i = i_0 e^{-t/CR}} \qquad i_0 = \frac{q_0}{CR}$$



Conducting sphere connected to each other by *a* wire :-

$$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$$



σ_1 and σ_2 is charge densities on two sphere