CAPACITOR

1 Capacitor

Capacitor is a passive device of the circuit which stores electrical energy or charge. It is also known as **condenser**.

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

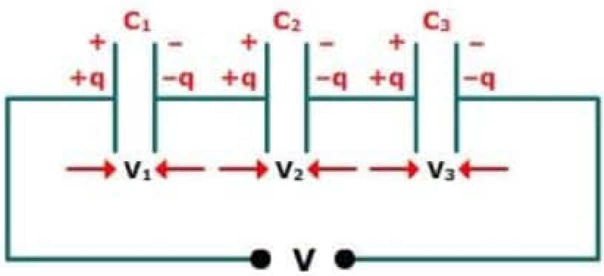
Capacitance is measured in **Farad (F)**

Q = Charge **A** = Area

V = Voltage **d** = Diameter

2 Combination

i Series



- Charge stored on each capacitor is same and equal to the magnitude of the charge, which comes from the battery..

$$Q = q_1 = q_2 = q_3$$

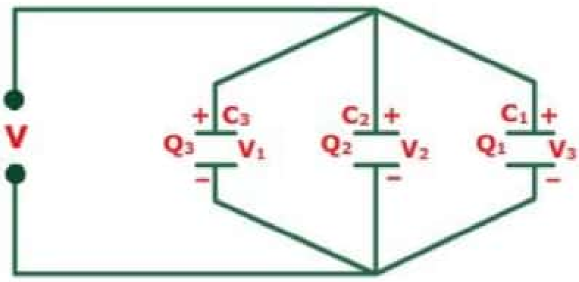
- The sum of voltage across the individual capacitor is equal to the voltage of the battery.

$$V = V_1 + V_2 + V_3$$

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

- Equivalent capacitance of the capacitor is always less than the smallest value of the capacitance of the capacitor in the circuit.

ii Parallel



- The Voltage across each capacitor is the same,and it is equal to the voltage of the battery.

$$V = V_1 = V_2 = V_3$$

- The sum of the charge stored on an individual capacitor is equal to the magnitude of the charge, which comes from the battery.

$$Q = q_1 + q_2 + q_3$$

- $C_{eq} = C_1 + C_2 + C_3$

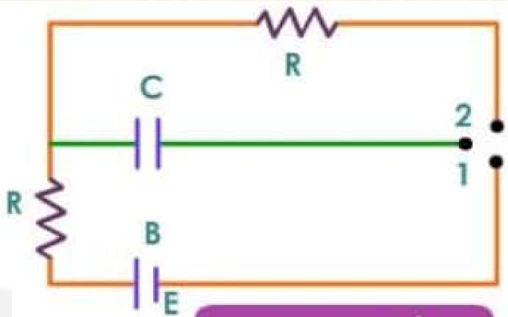
- Equivalent capacitance of the capacitor is always greater then the largest value of the capacitance of the capacitor in the circuit.

Part I

CIRCUIT SOLUTION

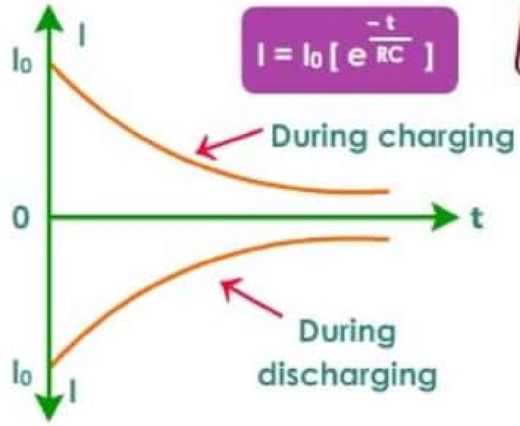
CHARGING AND DISCHARGING OF A CAPACITOR

CHARGING OF A CAPACITOR



$$q = q_0\left[1 - e^{\frac{-t}{RC}}\right]$$

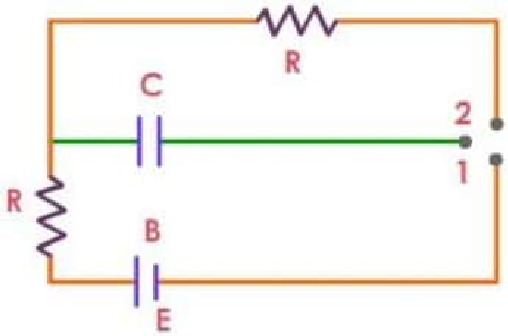
Where q_0 = maximum final value of charge at $t = \infty$.
Time $t = RC$ is known as Time Constant.



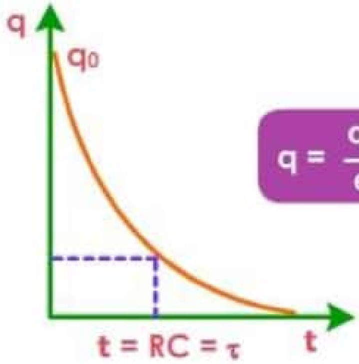
$$I = I_0\left[e^{\frac{-t}{RC}}\right]$$

If $t = RC = \tau$ = Time constant
Then, $I = 0.37\ I_0$

DISCHARGING OF A CAPACITOR



$$q = q_0\left[e^{\frac{-t}{RC}}\right]$$



$$q = \frac{q_0}{e} = 0.37q_0$$

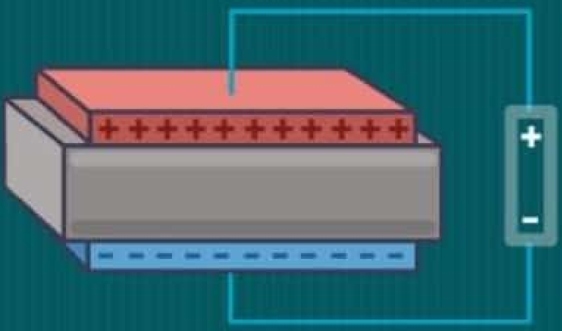
If $t = RC = \tau$ = time constant,
Then, $q = 0.37\ q_0$

FORCE BETWEEN THE PLATES OF A CAPACITOR

$$F = -\frac{d}{dx}\left[\frac{q^2}{2\varepsilon_0 A}x\right] = \frac{-1}{2}\frac{q^2}{\varepsilon_0 A}$$

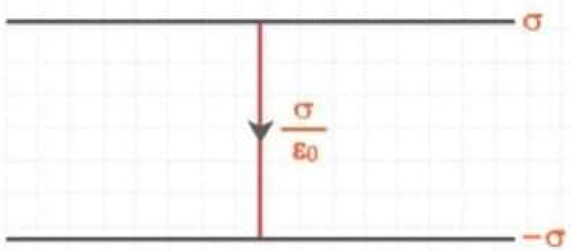
The negative sign implies that the force is attractive.

Part II



CAPACITOR WITH DIELECTRIC

1. Without Dielectric



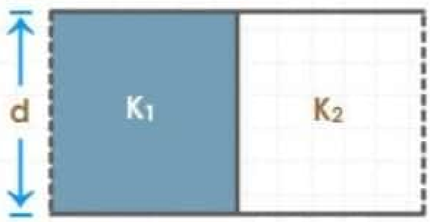
$$E = \frac{\sigma}{\varepsilon_0}$$

2. With Dielectric

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

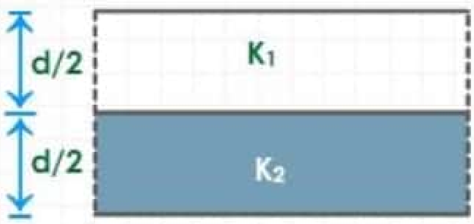
A = Area of Dielectric Slab

3. Dielectric Placed Vertically



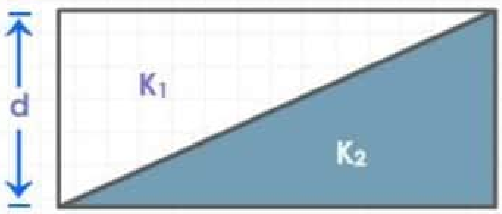
$$C = C_1 + C_2 \longrightarrow C = \frac{\varepsilon_0 (K_1+K_2)A}{2d}$$

4. Dielectric Placed Horizontally



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \longrightarrow C = \frac{2\varepsilon_0 A K_1 K_2}{(K_1+K_2)d}$$

5. Dielectric Placed Diagonally



$$C = \frac{\varepsilon_0 A K_1 K_2}{(K_2 - K_1)} \log_e \frac{K_1}{K_2}$$

6. Capacitor With 3 Dielectrics

$$C = \frac{\varepsilon_0 A}{d}\left[\frac{K_1}{2} + \frac{K_2 K_3}{K_2+K_3}\right]$$