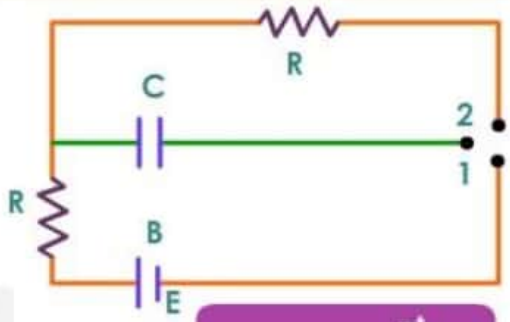
Part I

# CIRCUIT SOLUTION

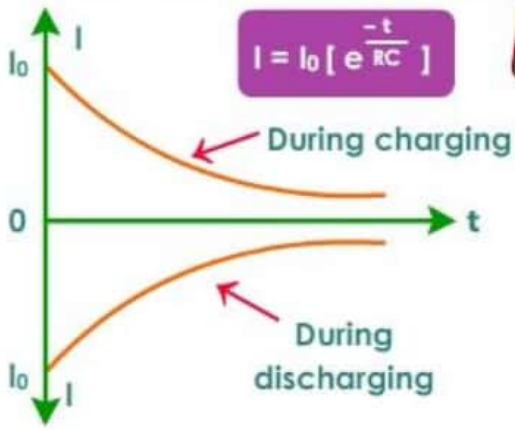
## CHARGING AND DISCHARGING OF A CAPACITOR

### CHARGING OF A CAPACITOR




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

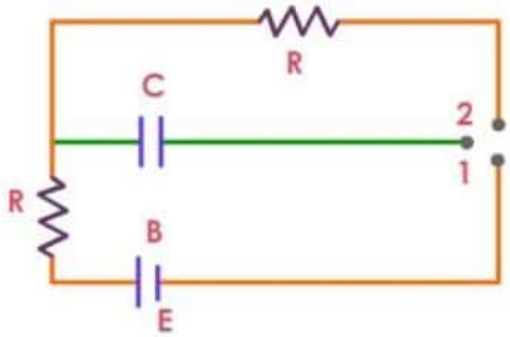
Where $q_0$ = maximum final value of charge at $t = \infty$.
Time $t = RC$ is known as Time Constant.



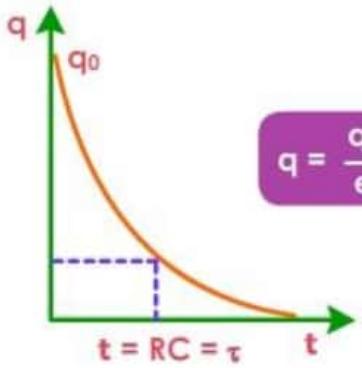

$$I = I_0 [e^{\frac{-t}{RC}}]$$

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

### DISCHARGING OF A CAPACITOR




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




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

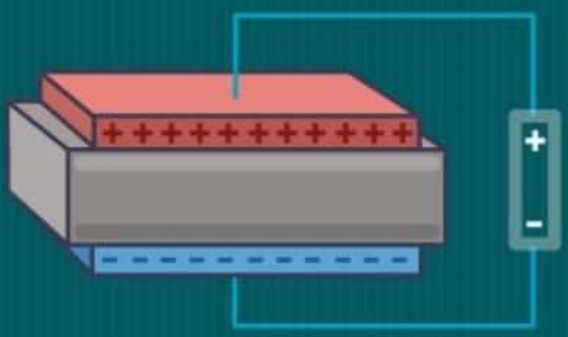
If $t = RC = \tau$ = time constant,
Then, $q = 0.37\ q_0$

### FORCE BETWEEN THE PLATES OF A CAPACITOR

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

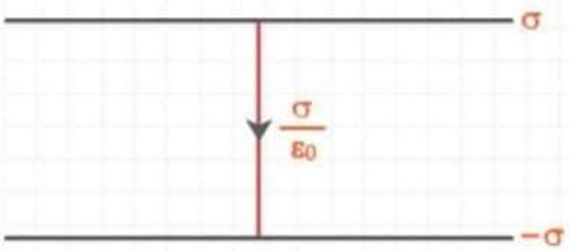
The negative sign implies that the force is attractive.

Part II



# CAPACITOR WITH DIELECTRIC

## 1. Without Dielectric




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

## 2. With Dielectric

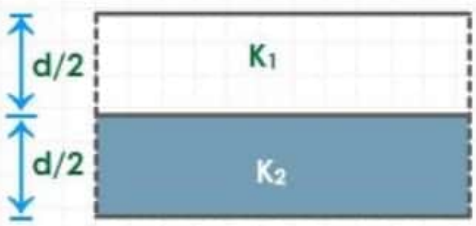

$$C = \frac{AK\varepsilon_0}{d}$$

A = Area of Dielectric Slab

## 3. Dielectric Placed Vertically

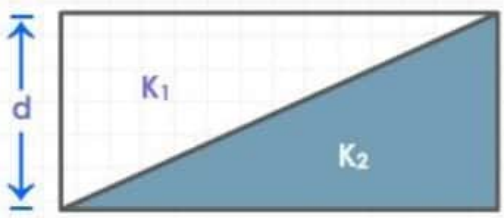

$$C = C_1 + C_2 \longrightarrow C = \frac{\varepsilon_0(K_1+K_2)A}{2d}$$

## 4. Dielectric Placed Horizontally



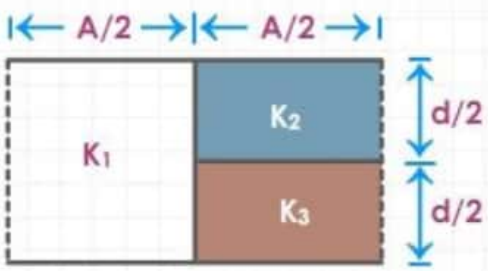

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \longrightarrow C = \frac{2\varepsilon_0 AK_1K_2}{(K_1+K_2)d}$$

## 5. Dielectric Placed Diagonally




$$C = \frac{\varepsilon_0 AK_1K_2}{(K_2-K_1)} \log_e \frac{K_1}{K_2}$$

## 6. Capacitor With 3 Dielectrics




$$C = \frac{\varepsilon_0 A}{d}\left[\frac{K_1}{2} + \frac{K_2K_3}{K_2+K_3}\right]$$