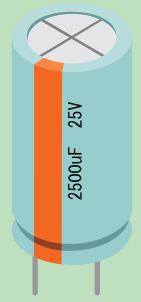
# CAPACITOR

## TYPES OF CAPACITANCE'S

- Capacitance of Spherical conductor:
  $C = 4\pi\varepsilon r$
- Capacitance of Earth: $C = 4\pi\varepsilon r$: $r = 6.4\times10^6 F$
  $\therefore C = 4\pi\times 8.854\times10^{-12}\times 6.4\times10^6 = 7.11\times10^{-4} F$
- Capacitance of Parallel Plate Capacitor:
  $(C_0) = \frac{\varepsilon_0 A}{d} F$

where— $\varepsilon_0$ = Free Space permitivity
$A$ = Plate Area
and $d$ = Sepration between Plates




## FORCE BETWEEN THE PLATES OF CAPACITOR

$F = \frac{\theta\sigma}{2\varepsilon_0} \Rightarrow F\frac{\theta^2}{2A\varepsilon_0} = \frac{1}{2}\varepsilon_0 AE^2$

$F$ = Force: $\theta$ = charge
$E$ = electric field between Plates
$\sigma$ = surface charge density

## ELECTROSTATIC PRESSURE

$(P) = \frac{F}{A} = \frac{\theta E}{A} = \frac{\sigma A}{A}\left(\frac{\sigma}{2\varepsilon}\right)$

$= \frac{1}{2}\frac{\sigma^2}{\varepsilon_0}$

## KIRCHOFF'S LAW OF CAPACITOR'S

FIRST LAW: This law is basically law of conservation of charge which states that the sum of incoming charges at a function in equal to the sum of outgoing charges

$q_{\_} = q_1 + q_2 = q_3 + q_4$

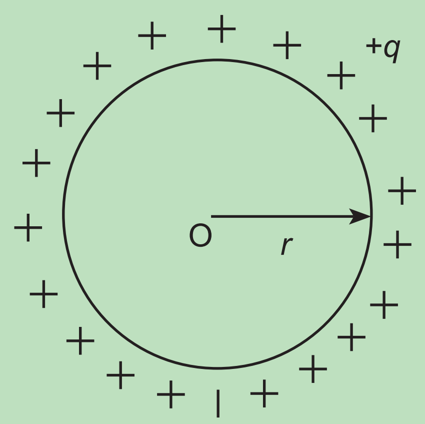
SECOND LAW: In a closed loop, the summation of all the potential differences must be zero.

$V - \frac{q_1}{C_1} - \frac{q_3}{C_3} = 0$

## OTHER TYPES OF CAPACITOR'S

- Sphrical Capacitor outer surface Earthed:

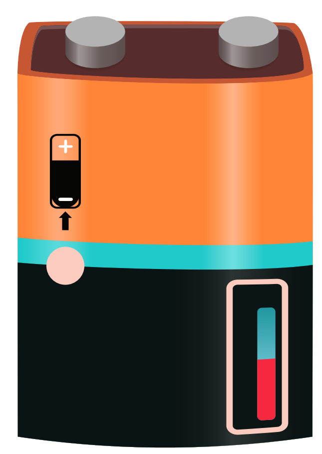
$C = \frac{\theta}{V} = \frac{4\pi\varepsilon_0}{\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$




- Cyllindrical Capacitor:

$C = \frac{4\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$

L. B and a - Parameters of Cyllinder

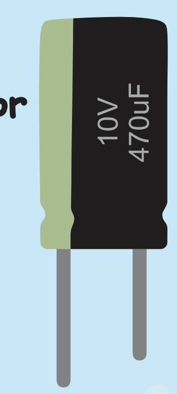


A capacitor is a device which can store more electric change or potential energy compared to on isolated conductor

- Capacitance: Capacitance of a conductor measure of its ability to store charge.

$V \propto q \Rightarrow V = \frac{q}{c} \Rightarrow C = \frac{q}{V}$

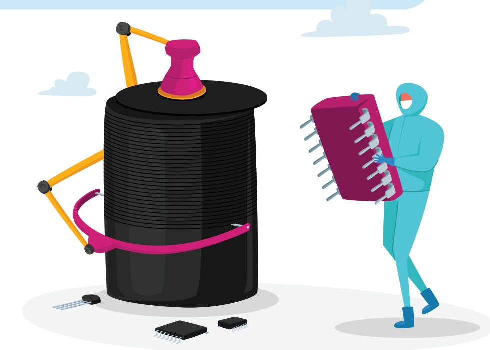
S.I. Unit Farad $(F) = \frac{\text{Coulomb}}{\text{Volt}}$




## DIELECTRIC

Dieletric is a material which behaves as non conductor upto certain value of external eletctric field. If the field crosses the limiting value (called dielectric strogth) then it beging to conduct
Dielectric constant (k or $E_R$)

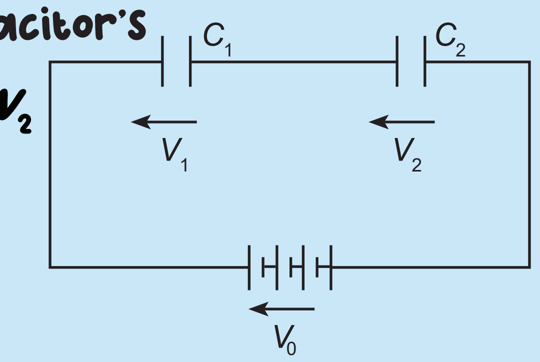
$E_r = K = \frac{E_m}{\varepsilon_0}$



## COMBINATION OF CAPACITOR'S

- Series equivalent of Capacitor's

In Series— $\theta = C_1V_1 = C_2V_2$
$\because V_0 = V_1 + V_2$
$\therefore \frac{1}{C_{equi}} = \frac{1}{C_1} + \frac{1}{C_2}$

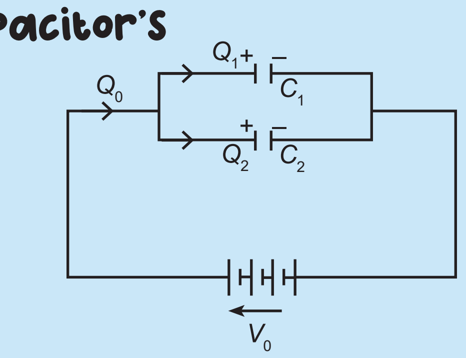



- Parallel equivalent of Capacitor's

In parallel— $V = V_1 = V_2$

$\theta = \theta_1 + \theta_2$

$C_{Equiv} = C_1 + C_2$




## CHARGING & DISCHARGING OF A CAPACITOR

- CHARGING:

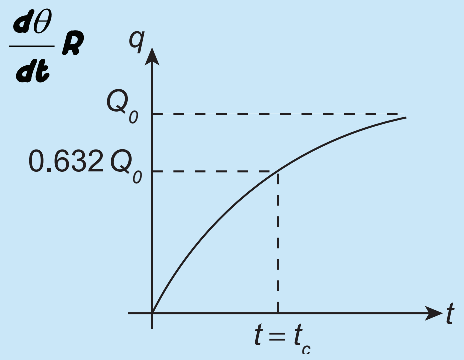
(i) Charging of a capacitor without Resistance
Charging take no time when switch closed
$q_0 = CV$

(ii) Charging of a Capacitor having Series Resistance:

$V_0 = V_C + V_R = \frac{\theta}{C} + IR = \frac{\theta}{C} + \frac{d\theta}{dt}R$

$Q = CV_0 e^{-\frac{t}{RC}} = Q_0 e^{-\frac{t}{T}}$

I = Current
R = Resistance
T = Time Constant = RC



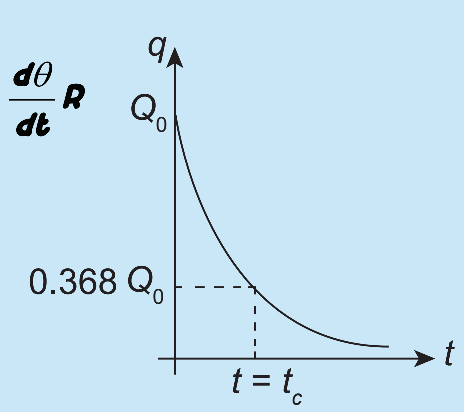

- Discharging of a capacitor through serias resistance:

$V_0 = V_C + V_R = \frac{\theta}{C} + IR = \frac{\theta}{C} + \frac{d\theta}{dt}R$

$\theta = \theta_0(1 - e^{-\frac{t}{T}})$

$\theta = 0.368\theta_0$

At time $t = RC$




## ENERGY STRORED IN A CHARGED CAPACITOR

$U = \frac{1}{2}\frac{\theta^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}\theta V$

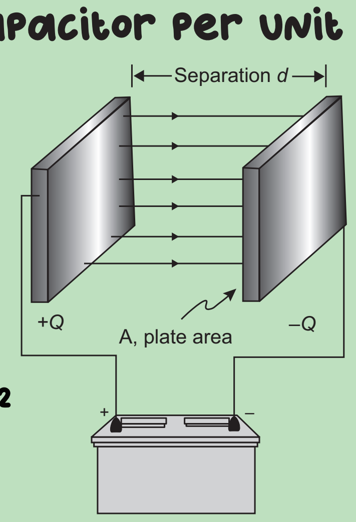
## WORK DONE BY BATTERY DURING CHARGING OF A CAPACITOR

$\Rightarrow W_{Battery} = \theta C = CV^2 = \frac{\theta}{C}$

## ENERGY DENSITY OF CAPACITOR

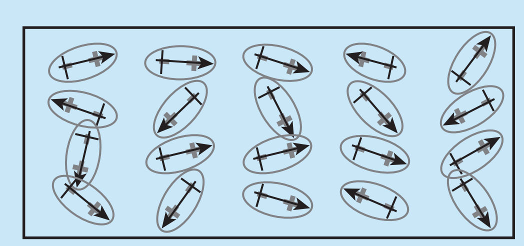
Energy stored in the capacitor per unit volume.
Energy density of capacitor $= \frac{dV}{dV}$

$\Rightarrow \left(\frac{U}{V}\right) = \frac{\frac{1}{2}CV^2}{A\times d} = \frac{1}{2}\varepsilon_0 F^2$



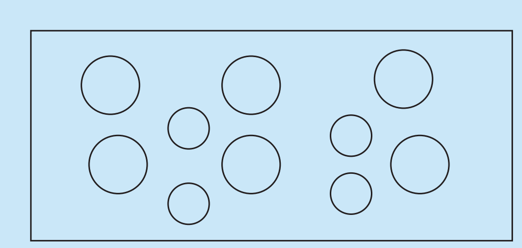

## POLAR DIELECTRIC

- Centers of +ve and −ve charge do not coincide due to asymmetric shape of molecules.
- Each molecule has permanent dipole moment in presence of external electric field



## NON-POLAR DIELECTRIC

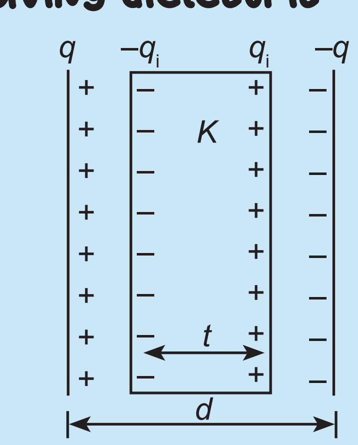
- Centers of +ve and −ve charge coincide due to symmetric shape of molecules.
- Each molecule has prmament dipole moment only in presence of external electric field



## CAPACITOR WITH DIELEATRIC

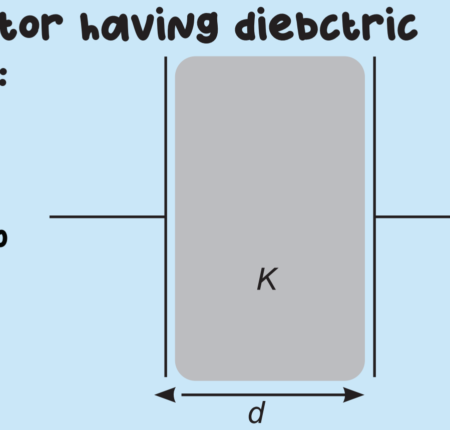
- Capacitance of capacitor having dielectric constant (k) and (t<d):

$C = \frac{A\varepsilon_0}{dd - t + \frac{t}{k}}$ $t$ = thickness
$k$ = Dieletric Constant




- Capacitance of Capacitor having diebctric constant (K) and (t = d):

$C = \frac{A\varepsilon_0}{d - d + \frac{d}{k}} = \frac{kA\varepsilon_0}{d} = kC_0$

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