## Gauss' Law

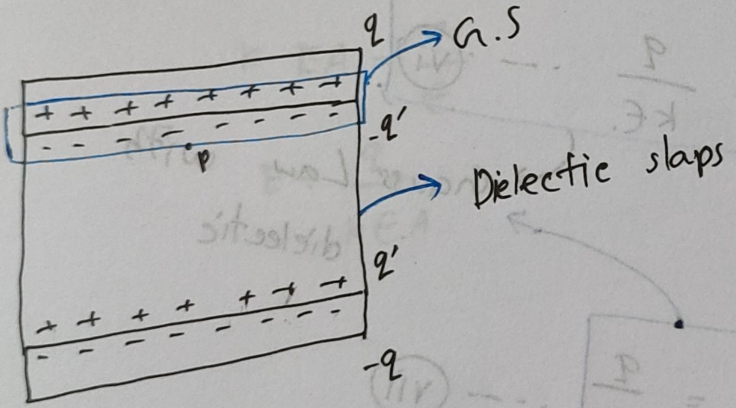
$$\Phi_E = \oint \vec{E} \cdot \vec{dA} = \frac{q_{enc}}{\epsilon_\circ}$$

$$\Phi_E = \oint \vec{E} \cdot \vec{dA} = \frac{q}{\epsilon_\circ} \quad \cdots \text{(i)}$$

$$E_\circ A = \frac{q}{\epsilon_\circ}$$

$$\therefore E_\circ = \frac{q}{\epsilon_\circ A} \quad \cdots \text{(ii)}$$

(ii) With dielectic:




Gauss' Law:

$$\Phi_E = \oint \vec{E}\, \vec{dA} = \frac{q_{enc}}{\epsilon_\circ}$$

$$\Phi_E = \oint \vec{E}\, \vec{dA} = \frac{q-q'}{\epsilon_\circ} \quad \cdots \text{(iii)}$$

$$EA = \frac{q-q'}{\epsilon_\circ}$$

$(E_\circ - E')$

$$E = \frac{q-q'}{\epsilon_0 A} \quad \cdots\cdots (iv)$$

$$\frac{E_0}{E} = k$$

$$\therefore E = \frac{E_0}{k}$$

$$E = \frac{q}{k\epsilon_0 A} = \frac{q-q'}{\epsilon_0 A}$$

$$\frac{q}{k} = q - q' \quad \cdots\cdots (v)$$

From - (iii),

$$\boxed{\phi_E = \oint \vec{E}\,\vec{dA} = \frac{q}{k\epsilon_0}} \quad \cdots\cdots (vi)$$

Gauss Law with dielectic

$$\Rightarrow \boxed{k\oint \vec{E}\cdot\vec{dA} = \frac{q}{\epsilon_0}} \quad \cdots\cdots (vii)$$

General form or Gauss' Law (with or without)

Prove:

(i) Without dielectic,

$k = 1$, Electric Field $= E_0$

$$\Phi_E = \oint \vec{E}\, d\vec{A} = \frac{q}{\epsilon_0}$$

$$E_0 . A = \frac{q}{\epsilon_0}$$

$$E_0 = \frac{q}{\epsilon_0 A}$$

(ii) With dielectic,

$k = k$, Electric Field, $E = E_0 - E'$

$$k \oint \vec{E}\, d\vec{A} = \frac{q}{\epsilon_0}$$

$$k . EA = \frac{q}{\epsilon_0}$$

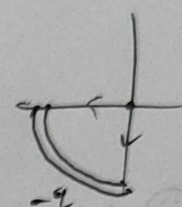
$$E = \frac{q}{k \epsilon_0 A}$$

L-19/03.04.2023/

## Midterm Exam

L-19/05.03.2023/

$$\boxed{E=\int_0^{\pi/2} dE\cos\theta + \int_0^{\pi/2} dE\sin\theta}$$



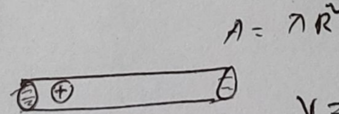

Example: On dielectic (Text Book) — Assignment.

## ⊛ Resistance and Current:

### ⊛ Current:

$i = \dfrac{q}{t}$

$\therefore q = it$




$V = A \cdot L$

$dq \to dt$ ; $i = \dfrac{dq}{dt}$

$\therefore \int_0^q dq = \int_0^t i\,dt$

$\Rightarrow q = it$

direction:

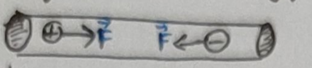
$\oplus \longrightarrow$

$\longrightarrow$ Current direction

$\ominus \longrightarrow$

C. Dire: $\longleftarrow$

⊛



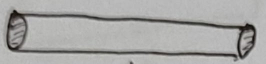

$\longrightarrow \vec{E}$ $L = 2m$

$V = Ed$

$E = \frac{V}{d} = \frac{10}{2} = 5\ V/m$

$\vec{F} = q\vec{E}$

⊛




$R \propto L$

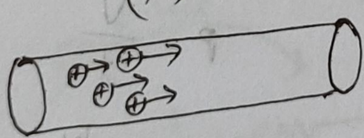
$R \propto \frac{1}{A}$

$R \propto \frac{L}{A}$

$R = \rho \frac{L}{A}$ ; $\rho$ = resistivity

⊛

$(A, L)$

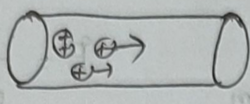


$i = \frac{q}{t}$

$j = \frac{i}{A}$ = current density

$v_d$ = drift velocity, $n$ = numbers density of the current.

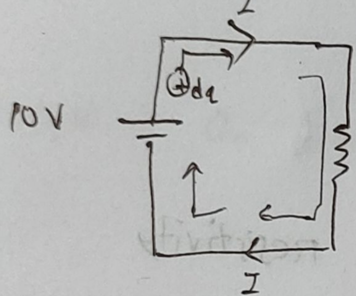
$t = \frac{L}{v_d}$



$$+(AL)ne = q$$

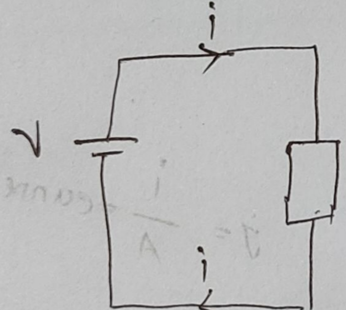
$$i = \frac{q}{t} = \frac{ALne}{\frac{L}{v_d}} = Ane\,v_d$$

## Power:




$$dq \to dt$$

$$i = \frac{dq}{dt} \quad \therefore \quad dq = i\,dt$$




$$P = \frac{V}{t}$$

$$P = \frac{du}{dt}$$

$$U = Vq$$

$$du = V\,dq$$

$$du = V\,i\,dt$$

$$\boxed{\therefore P = VI}$$

→ Power

$$\boxed{P = \frac{du}{dt} = Vi}$$

$$V = iR$$

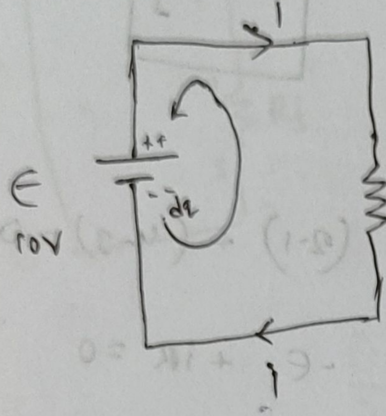
$$P = Vi$$

$$P = iRi$$

$$\boxed{P = i^2R}$$

L-20 / 10.04.2023 /

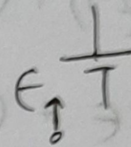
## ⊛ Circuits!




$$i = \frac{dq}{dt}$$

$$dq = dt$$

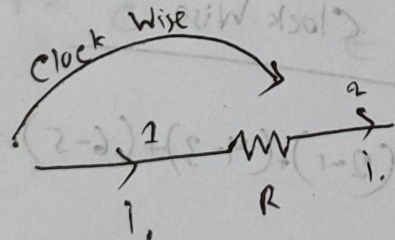
$\epsilon$



$dq \rightarrow dW$

$\rightarrow \frac{dW}{dq}$ per unit

$= \epsilon$ - EMF (Electro motive Force)

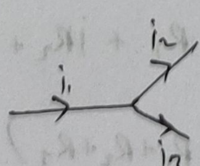



$V = iR$

$$V_2 - V_1 = -iR$$

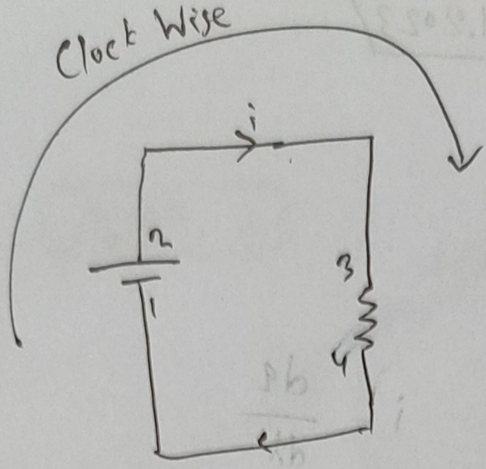
## ⊛ Kirchof's Law

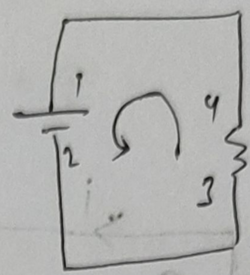
(i) KCL:




$i_1 = i_2 + i_3$

(ii) KVL: $\sum_i V_i = 0$ $\quad V_1 + V_2 = 0$




$$(2-1) + (4-3) = 0$$

$$+\epsilon + (-iR) = 0$$

$$+\epsilon - iR = 0$$

$$\epsilon = iR$$

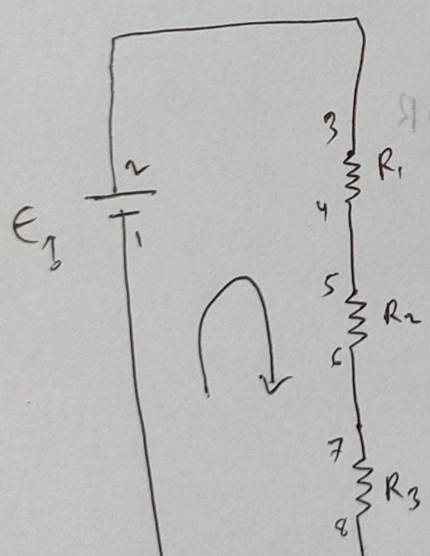
$$i = \frac{\epsilon}{R}$$

$$(2-1) + (4-3) = 0$$

$$-\epsilon_i + iR = 0$$

$$\epsilon = iR$$

$$i = \frac{\epsilon}{R}$$




Clock Wise

$$(2-1) + (4-3) + (6-5) + (8-7) = 0$$

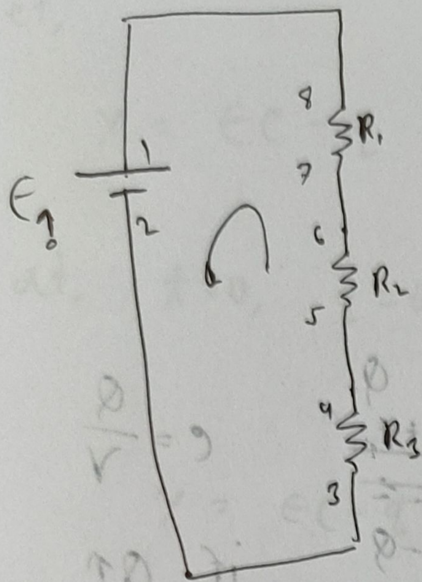
$$\epsilon + (-iR_1) + (-iR_2) + (-iR_3) = 0$$

$$\epsilon - iR_1 - iR_2 - iR_3 = 0$$

$$\epsilon = iR_1 + iR_2 + iR_3$$

$$\epsilon = i(R_1 + R_2 + R_3)$$

$$i = \frac{\epsilon}{R_1 + R_2 + R_3}$$



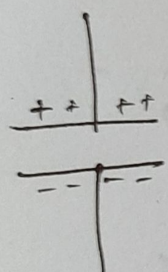

## Anti Clock Wise

$$(2-1)+(4-3)+(6-5)+(8-7)=0$$

$$\epsilon + iR_3 + iR_2 + iR_1 = 0$$

$$\epsilon = i(R_1+R_2+R_3)$$

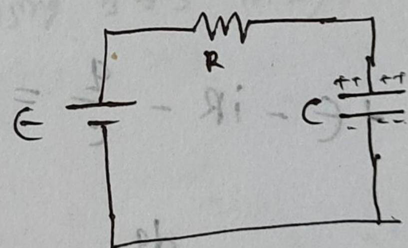
$$i = \frac{\epsilon}{R_1+R_2+R_3}$$



$$C = \left|\frac{Q}{V}\right|$$

(i) Changing RC Circuit

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




$t = 0$

$q = 0$

$t\uparrow - q\uparrow$

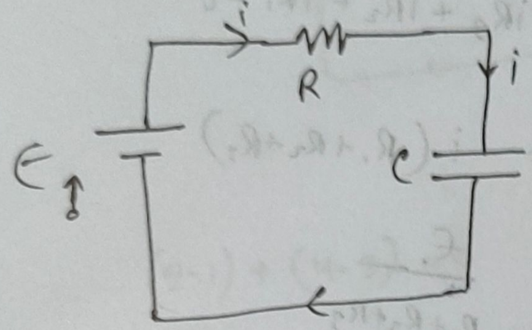
$$i = \frac{dq}{t}$$

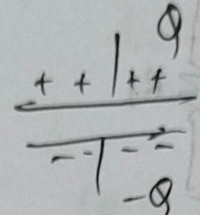
$$V = \frac{Q^{=0}}{C} = 0$$

$$+\epsilon - iR - \frac{q(t)}{C} = 0 \quad \text{----} \quad (1)$$

L-21/ 12.04.2023/

## (i) Changing RC Circuit:




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

if, $Q \uparrow$

$\Rightarrow V \uparrow$

$\because C =$ constant

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

at, $t = 0$, $q = 0$ ; $V = \frac{q}{c} = 0$

$t\uparrow$ , $q\uparrow$ ; $V\uparrow$

$+\epsilon - iR - \frac{q}{c} = 0$ ; $i = \frac{dq}{dt}$

$\epsilon - \frac{dq}{dt} R - \frac{q}{c} = 0$ --- (i)

This is a differential equation of charge (q) in time t.

$\epsilon - \frac{q}{c} = \frac{dq}{dt} R$

$\frac{c-q}{RC} = \frac{dq}{dt}$ --- (ii)

Let,

$$y = \epsilon C - q \quad \cdots \text{(iii)}$$

at, $t=0$, $q=0$ ; $\therefore y = \epsilon C = y_0 \quad \cdots \text{(iv)}$

$$y = \epsilon C - q \quad \cdots \text{(iii)}$$

$$\frac{dy}{dt} = 0 - \frac{dq}{dt}$$

$$-\frac{dy}{dt} = \frac{dq}{dt} \quad \cdots \text{(v)}$$

$$\frac{y}{RC} = -\frac{dy}{dt} \quad \text{(using 3 \& 5 in 2)}$$

$$\Rightarrow \frac{dt}{RC} = \frac{-dy}{y}$$

$$\Rightarrow \frac{dy}{y} = -\frac{dt}{RC}$$

$$\Rightarrow \int \frac{dy}{y} = -\int \frac{dt}{RC}$$

constant of integral

$$\ln y = -\frac{t}{RC} + k \quad \cdots \text{(vi)}$$

at $t=0,\ y = \epsilon C = y_0$

$$\ln y_0 = 0 + k$$

$$\therefore k = \ln y_0 \text{ --- (vii)}$$

$$\therefore \ln y = -\frac{t}{RC} + \ln y_0$$

$$\ln y - \ln y_0 = -\frac{t}{RC}$$

$$\ln\left(\frac{y}{y_0}\right) = -\frac{t}{RC}$$

$$\therefore \frac{y}{y_0} = e^{-t/RC}$$

$$y = y_0 e^{-t/RC}$$

$$\epsilon C - q = \epsilon C\, e^{-t/RC} \quad \text{(using 3 \& 4)}$$

$$\epsilon C - \epsilon C\, e^{-t/RC} = q$$

$$q(t) = \epsilon C\left(1 - e^{-t/RC}\right) \text{ ...... (viii)}$$

Solution of equation - 1

$$E - \frac{dq}{dt}R - \frac{q}{C} = 0 \quad \text{--- (i)}$$

$$q(t) = EC\left(1 - e^{-t/RC}\right) \quad \text{--- (8)}$$

⊗ $t = 0$;

$$q(0) = EC\left(1 - e^{0}\right)$$

$$= EC(1-1) = 0$$

⊗ $t \uparrow \infty$

$t = \infty$,

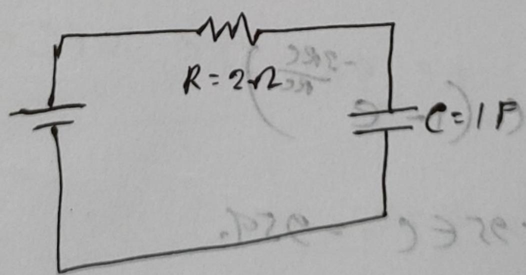
$$q(\infty) = EC\left(1 - e^{-\frac{\infty}{RC}}\right)$$

$$= EC(1-0)$$

$= EC$ → Maximum charge at $\infty$ time.

⊗

$E_1 = 100V$




⊗ $q(\infty) = EC = 100 \cdot 1 = 100$ coul.

$$q(RC) = EC\left(1 - e^{-\frac{RC}{RC}}\right)$$

$$= EC\left(1 - e^{-1}\right) = 0.63\,EC = 63\% \text{ of } q_{max}$$

$= 63$ coul.

⊗ 1 RC time = 63%.

$R = 2$
$C = 1$ } $RC = 2 \cdot 1 = 2$ sec

RC = Time constant

$\therefore$ $q(RC) = 0.63 \times 100 \times 1$

$= 63$ coul. (2 sec)

⊗ $t = 2RC$

$q(2RC) = EC\left(1 - e^{-\frac{2RC}{RC}}\right)$

$= EC\left(1 - e^{-2}\right)$

$= 0.86\,EC = 86\%$ of $q_{max}$

$= 86$ coul. (4 sec)

⊗ $t = 3RC$

$q(3RC) = EC\left(1 - e^{-\frac{3RC}{RC}}\right)$

$= 0.95\,EC = 95\%$

$= 95$ coul. (6 sec)

⊗ $t = 5RC$

$q(5RC) = EC\left(1 - e^{-\frac{5RC}{RC}}\right)$

$= 0.9932\,EC = \cancel{0.993} \; 99.32\%$

$= 99.32$ coul. (10 sec)

⊛ $t = 10RC$

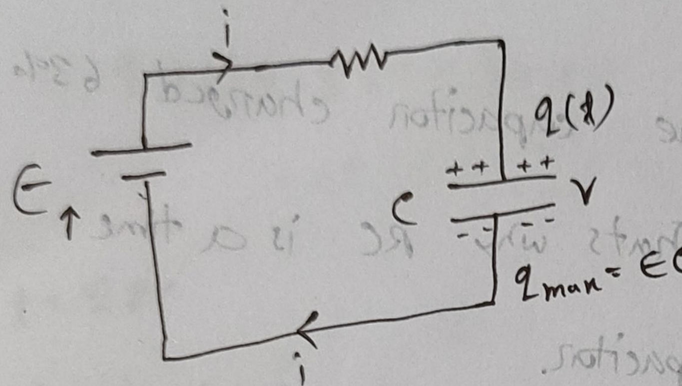
$q(10RC) = \cancel{0.99 \times 99\,E}\ \ 0.9999\,EC = 99.99\,d.$

$= 99.99$ Coul. (20 sec)

⊛ In every RC time capaciton charged 63% of empty space. Thats why RC is a time constant fon a capaciton.

L-22/ 17.04.2023/

## ⊛ Changing RC Circuits:




at, $t=0$

$q=0$; $V=0$; $C = \frac{Q}{V}$

$\therefore V = \frac{Q}{C} = \frac{0}{C} = 0$

$t\uparrow$, $q\uparrow$, $V\uparrow$

$$\epsilon - iR - \frac{q}{C} = 0$$

$$\epsilon - \frac{dq}{dt}R - \frac{q}{C} = 0$$

$$q = \epsilon C\left(1 - e^{-t/RC}\right)$$

⊛ $t = 0,\ RC,\ 2RC,\ 5RC,\ 10RC,\ \infty$

$t = 0,\quad q = 0$

$t = RC,\quad q = 0.63\,\epsilon C$

$t = \infty,\quad q = \epsilon C = q_{max}$

Example:

$\epsilon = 100$ Volts

$R = 2\Omega$

$C = 1F$

$q_{max} = \epsilon C = 100 \times 1 = 100$ Coul

$t = \infty$,

$t = 5RC$, $q = 0.9932\, \epsilon C$

$= 99.32\%$

$t = 10RC$, $q = 0.9999\, \epsilon C$

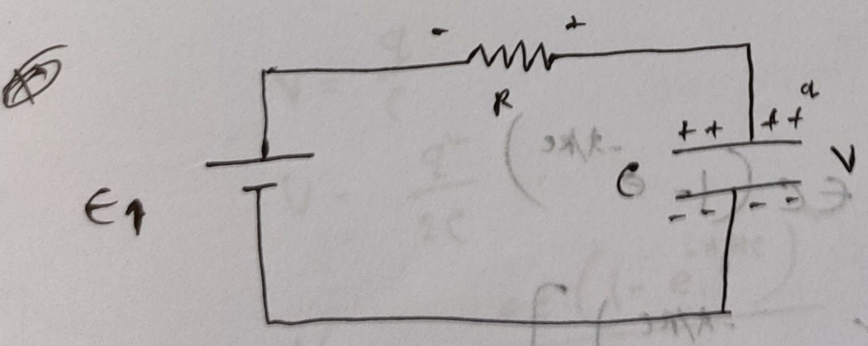
$= 99.99\%$

$RC = 2 \cdot 1 = 2$ sec

$10RC = 20$ sec

in 20 sec $99.99\% \Rightarrow q_{max}$

$\approx 100\%$




$\epsilon\uparrow, q\uparrow, V\uparrow$

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

$U = \frac{q^2}{2C}$

(i) Charge $q = \epsilon C(1 - e^{-t/RC})$

(ii) Potential Difference between the plates of the Capacitor (Voltage), V :

$$V = \frac{q}{C} = \frac{\epsilon C(1 - e^{-t/RC})}{C} = \epsilon(1 - e^{-t/RC})$$

$$V = \epsilon(1 - e^{-t/RC}) = V_c$$

$t = 0,$

$$V = \epsilon(1 - e^{-0/RC})$$

$$= \epsilon(1 - 1) = 0$$

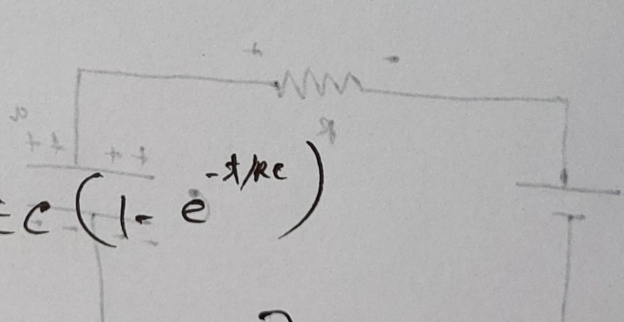
$t = \infty,$

$$V = \epsilon(1 - e^{-\infty/RC})$$

$$= \epsilon \cdot 1$$

$$= \epsilon$$

(iii) Current :



$$i = \frac{dq}{dt} \; ; \; q = \epsilon C(1 - e^{-t/RC})$$

$$i = \frac{d}{dt}\left[\epsilon C(1 - e^{-t/RC})\right]$$

$$i = \epsilon C\left[0 - \frac{e^{-t/RC}}{-RC}\right]$$

$$i = \epsilon C \left[ \frac{e^{-t/RC}}{RC} \right]$$

$$\boxed{i = \frac{\epsilon}{R} e^{-t/RC}}$$

Now, $t = 0, RC, 2RC, 3RC \cdots \infty$

$i = ?$

$t = 10RC$; $i = \frac{\epsilon}{R} e^{-10RC/RC}$

$$i = \frac{\epsilon}{R} e^{-10} = 4.5 \times 10^{-5} \frac{\epsilon}{R}$$

$$i = \frac{100}{2} = 50 A$$

## (iv) Stored Energy in the capacitor:

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

$$U = \frac{q^2}{2C}$$

$$U = \frac{\epsilon C \left(1 - e^{-t/RC}\right)^2}{2C}$$

$$U = \frac{1}{2} C \epsilon^2 \left(1 - e^{-t/RC}\right)^2$$

$t = 0$ ; $V = 0$

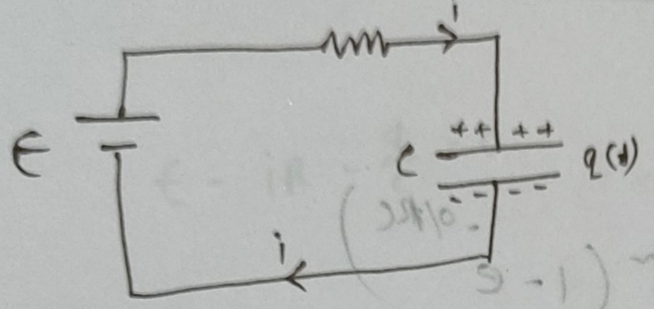
$t = \infty$ ; $V = max$

$t = 0, RC, 2RC, 10RC \ldots \infty$

$V = ?$

L-23 / 26.04.2023

## (i) Changing RC circuit:



$t = 0$, $q = 0$

$t \uparrow$, $q \uparrow$

$v = v_C \uparrow$

$t = \infty$

$q = \epsilon C$

$= q_{max}$

(i) $q = \epsilon C\left(1 - e^{-t/RC}\right)$

(ii) $v = v_c = \epsilon\left(1 - e^{-t/RC}\right)$

(iii) $i = \frac{\epsilon}{R} e^{-t/RC}$

## (iv) Stored energy in the capacitor:

$U = \frac{q^2}{2C} = \frac{q^2}{2C}$ ; $q = \epsilon C\left(1 - e^{-t/RC}\right)$

$t \uparrow$, $U \uparrow$, $U = \frac{q^2}{2C} = \frac{\left(\epsilon C\left(1 - e^{-t/RC}\right)\right)^2}{2C}$

$$U = U_C = U_E = \frac{\epsilon^2 C^2 \left(1 - e^{-t/RC}\right)^2}{2C}$$

$$\boxed{\therefore U(t) = \frac{1}{2} \epsilon^2 C \left(1 - e^{-t/RC}\right)}$$

$t = 0,$

$$U(0) = \frac{1}{2} \cdot C \cdot \epsilon^2 \left(1 - e^{-0/RC}\right)$$

$$= \frac{1}{2} C \cdot \epsilon^2 \cdot 0 = 0$$

## ⊛ During Charging:

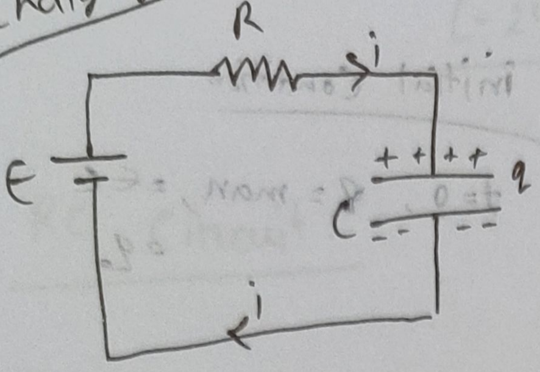
(i) Charge $q(t) = \epsilon C \left(1 - e^{-t/RC}\right)$

(ii) Voltage $= V = V_C = \epsilon \left(1 - e^{-t/RC}\right)$

(iii) Current $= i = \frac{\epsilon}{R} \cdot e^{-t/RC}$

(iv) Energy $= U = U_C = U_E = \frac{1}{2} C \epsilon^2 \left(1 - e^{-t/RC}\right)^2$

## Changing:




$t = 0,\ q = 0$

$t\uparrow,\ q\uparrow$

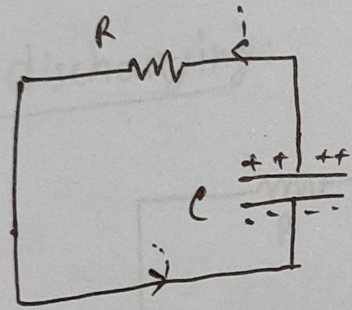
$q = \epsilon C\left(1 - e^{-t/RC}\right)$

$t = \infty,\ q = \epsilon C\left(1 - e^{-\infty/RC}\right)$

$q = \epsilon C = q_{max}$

$$\epsilon - iR - \frac{q}{C} = 0$$

## Dischanging:




$t = 0,$

$q = q_{max} = \epsilon C$

$t\uparrow,\ q\downarrow$

$$-iR - \frac{q}{C} = 0 \quad \text{--- (i)}$$

$$-\frac{dq}{dt}R - \frac{q}{C} = 0; \quad \left[i = \frac{dq}{dt}\right]$$

DE during dischan

$$-\frac{dq}{dt}R = \frac{q}{C}$$

DE of charge (q) in the time (t).

$$\int \frac{dq}{q} = -\int \frac{dt}{RC}$$

$q\downarrow,\ q(t),\ t\uparrow,\ q\downarrow$

$$\ln q = -\frac{t}{RC} + k; \quad \text{--- (ii)}$$

[k is a constant ~~of int~~ of integral]

Set, $t=0$, $q = q_0 = \epsilon C$

$\ln q_0 = 0 + k$

$\ln q_0 = k$ ---- (iii)

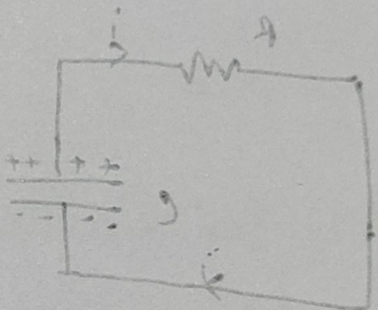
Initial Condition

$t = 0$, $q = max, = \epsilon C$
$= q_0$

$\therefore \ln q = -\dfrac{t}{RC} + \ln q_0$

$\ln q - \ln q_0 = -\dfrac{t}{RC}$

$\ln \dfrac{q}{q_0} = -\dfrac{t}{RC}$



$\dfrac{q}{q_0} = e^{-t/RC}$

$q = q_0 \, e^{-t/RC}$

(i) change: $\boxed{q = \epsilon C \; e^{-t/RC}}$ ---- (iv) $\left( \because q_0 = \epsilon C \right)$

solution of (i)

$t = 0$, $q = \epsilon C = q_{max}$

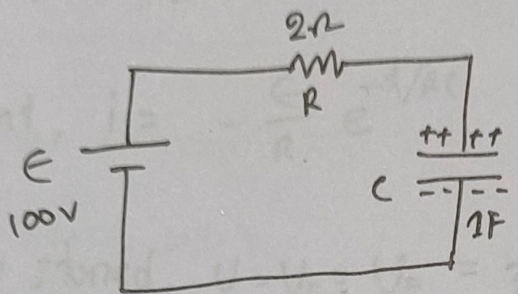
$t = RC$, $2RC \cdots \infty$

$q = ?$

L-24 / 03.05.2023 /

## RC Circuit :

### ⊛ During Charging :



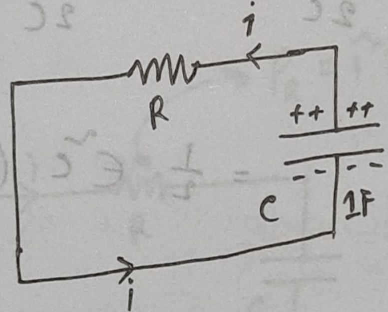

$t = 0$ , $q = 0$

$t \uparrow$ , $q \uparrow$

$q = q_{max} = \epsilon C$

$= 100 C$

### ⊛ During discharging :




$t = 0$, $q = \epsilon C$

$t \uparrow$, $q \downarrow$

$V_c = \downarrow$

$U \downarrow$

(i) $q(t) = q_0 \, e^{-t/RC}$

$= \epsilon C \, e^{-t/RC}$

(ii) Potential Difference between the plates of the capacitor

(Voltage $V_c$)

$$V = V_c = \frac{q}{C} = \frac{\epsilon C \, e^{-t/RC}}{C} = \epsilon \, e^{-t/RC}$$

(iii) Current:

$$i = \frac{dq}{dt} \quad ; \quad q = \epsilon C e^{-t/RC}$$

$$= \frac{d}{dt}\left(\epsilon C e^{-t/RC}\right)$$

$$= -\frac{\epsilon C e^{-t/RC}}{RC}$$

$$= -\frac{\epsilon}{R} e^{-t/RC}$$

(iv) Energy stored in the capacitor:

$$U = U_c = U_E = \frac{Q^2}{2C} = \frac{q^2}{2C} = \frac{\epsilon^2 C^2 e^{-2t/RC}}{2C}$$

$$= \frac{1}{2} \epsilon^2 C \left(e^{-t/RC}\right)^2$$

## During Discharging:

(i) Charge, $q(t) = \epsilon C \, e^{-t/RC}$

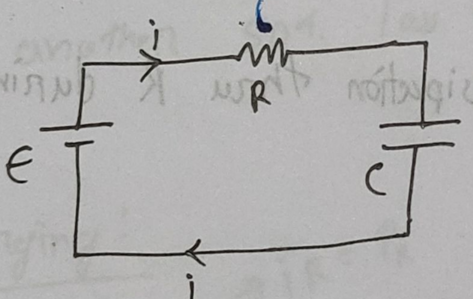
(ii) Voltage, $V = V_c = \epsilon e^{-t/RC}$

(iii) Current, $i = -\frac{\epsilon}{R} e^{-t/RC}$

(iv) Energy stored, $U = U_c = U_E = \frac{1}{2} \epsilon^2 C \left(e^{-t/RC}\right)^2$

## More on energy:

$P_R = i^2 R$ = energy consumed here 50%.




$\boxed{V = VQ}$

(i) Supplied energy by the battery during charging

Process:

$$Q = q_{max} = \epsilon C$$

Supplied energy by battery

$$U_\epsilon = \epsilon \cdot \epsilon C = \epsilon^2 C$$

(ii) Total stored energy in capacitor during charging

Process:

$$U_c = U = \frac{q^2}{2C} = \frac{q_{max}^2}{2C} = \frac{(\epsilon C)^2}{2C}$$

$$= \frac{1}{2}\epsilon^2 C$$

= Capacitor can store 50% of the supplied energy.

(iii) Energy loss thru the ressistor R during charging

$$P = \frac{dU_R}{dt} = i^2 R$$

= Power dissipation thru R during charging

$$= i^2 R \, dt$$

$dU_R$ = energy loss in time $dt$

$$U_R = \int dU_R = \int_{t=0}^{\infty} i^2 R \, dt$$

$$U_R = \int_0^{\infty} \left(\frac{\epsilon}{R} e^{-t/RC}\right)^2 R \, dt$$

$$= \frac{\epsilon^2}{R^2} \cdot R \int_0^\infty e^{-2t/RC} \, dt$$

$$= \frac{\epsilon^2}{R} \int_0^\infty e^{-2t/RC} \, dt$$

$$= \frac{\epsilon^2}{R} \left[ \frac{e^{-2t/RC}}{\frac{-2}{RC}} \right]_0^\infty$$

$$= \frac{\epsilon^2}{R} \cdot \frac{RC}{-2} \cdot e^{-2t/RC} \Big]_0^\infty$$

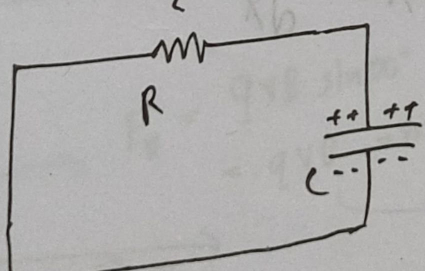
$$= -\frac{1}{2} \epsilon^2 C \cdot (0-1)$$

$$= \frac{1}{2} \epsilon^2 \cancel{R} C$$

= another 50% loss during changing.

## ⊛ Discharging:

$i^2R = P_R$




$$V_c = \frac{1}{2} \epsilon^2 C$$

(iv) Energy loss during discharging thru the R.

$$P_R = \frac{dU_R}{dt} = i^2 R$$

$dU_R = i^2 R\, dt$ = energy loss in the time $dt$ during discharging.

$$U_R = \int dU_R = \int_{t=0}^{\infty} i^2 R\, dt$$

$$= \int_0^{\infty} \left( -\frac{\epsilon}{R} e^{-t/RC} \right)^2 R\, dt$$

$$= \int_0^{\infty} \frac{\epsilon^2}{R^2} \cdot R \cdot e^{-2t/RC}\, dt$$

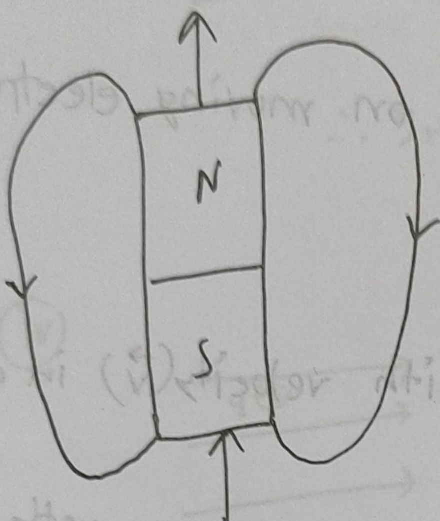
$$= \frac{\epsilon^2}{R} \int_0^{\infty} e^{-2t/RC}\, dt$$

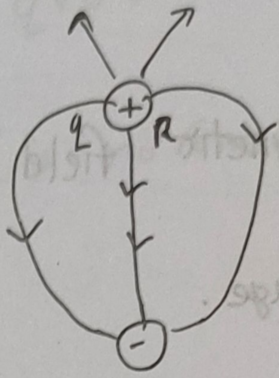
$$= \frac{1}{2} \epsilon^2 C$$

(*) After one cycle of charging and one cycle of discharging, there is no remaining energy in the system.

L-25/08.05.2023/

# ⊛ Magnetic Field ($\vec{B}$)



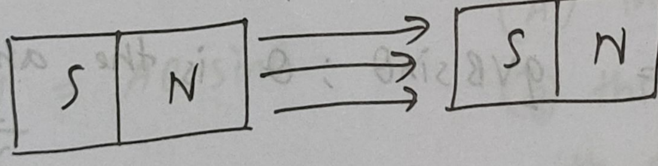




$k \cdot \frac{q}{r}$

$\boxed{N} \rightarrow \times$ impossible

There is no isolated magnetic monopole.

⊛

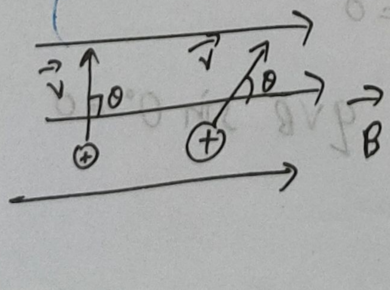



(i)

$F_B = qvB \sin 90^\circ$

$= qvB$ = maximum force

$B = \frac{F_B}{qv}$ → maximum force



* A moving change enpeniences magnetic force ~~&~~ of a ..

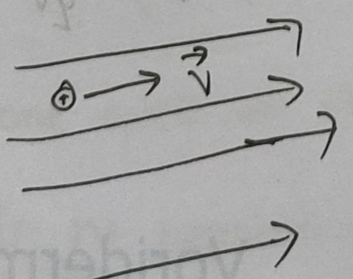
* Magnetic field exents force on moving electric change.

* A change (q) is moving with veloeity ($\vec{v}$) in a magnetic field ($\vec{B}$) enpeniences a magnetic force ($\vec{F}_B$).

$$\vec{F}_B = q\vec{v} \times \vec{B}$$

$|\vec{F}_B| = qvB \sin\theta$ ; $\theta$ is the angle between $\vec{v}$ & $\vec{B}$

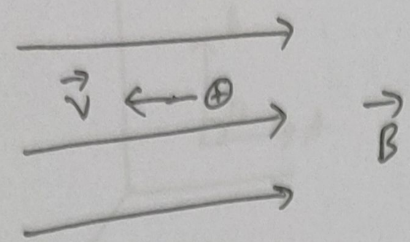
(ii)



$\theta = 0^\circ$

$F_B = qvB \sin 0^\circ = 0$

(iii)

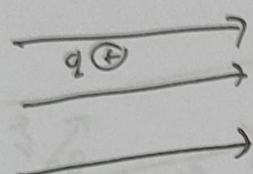



$\theta = 180°$

$F_B = qvB \sin 180° = 0$

$\therefore$ In Parallel there is no force.

(iv)




$\vec{F}_B = q\vec{v} \times \vec{B}$

$= 0$

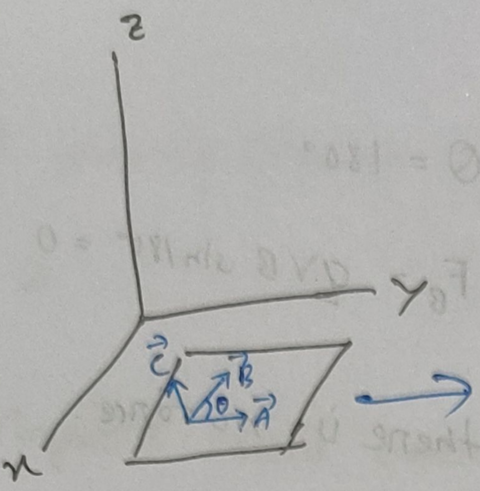
## ⊛ Cross Product:

$\vec{C} = \vec{A} \times \vec{B}$

$|C| = AB \sin\theta$

## ⊛ Right hand Rule:

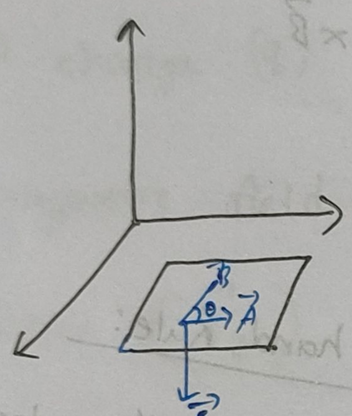
→ Sweep the 1st vector ($\vec{A}$) into the second vector ($\vec{B}$) thru smaller angle, ~~with~~ with the right hand direction of thumb is the direction of $\vec{C} = (\vec{A} \times \vec{B})$




→ Horizental Plane

$\vec{C}$ = up (+z)

= AB sin$\theta$

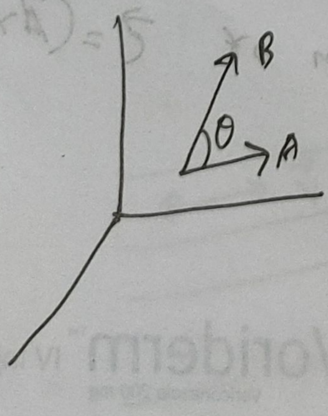



$\vec{C}' = \vec{B} \times \vec{A}$ = BA sin$\theta$

= down (-z)

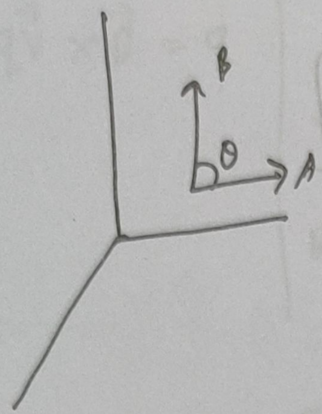
$\otimes$ $\odot$ → Out of the page

→ Into the page




$\vec{C} = \vec{A} \times \vec{B}$ $\odot$

= towards me




$\vec{C} = \vec{B} \times \vec{A}$

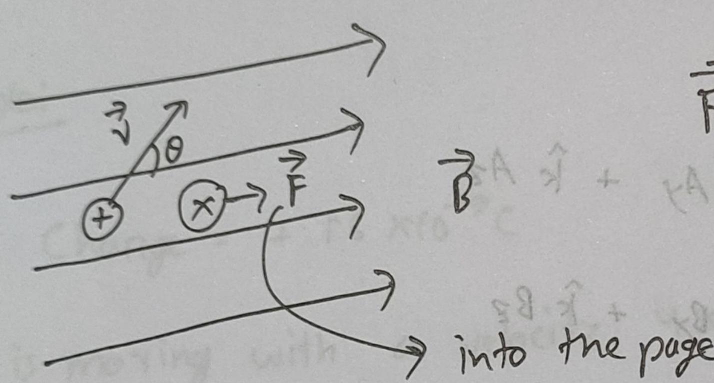
= from me

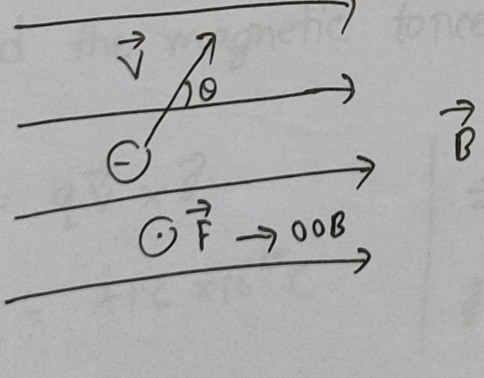
= ⊗

= Into the page

$\vec{F}_B = q\vec{v} \times \vec{B}$

$|F_B| = qvB\sin\theta$




$\vec{F}_B = -q\vec{v} \times \vec{B}$

$= -q($ into the page$)$

= Out of the page