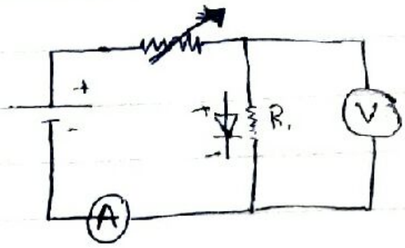
① Ex: linear and non-linear Componants.

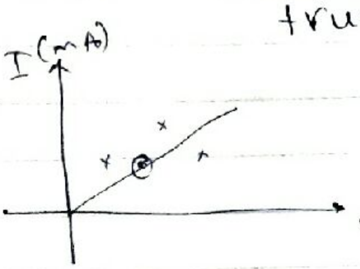
→ Ohm's law: R indep. on V and I.

$$R = \frac{V}{I}$$

1 Carbon R :-

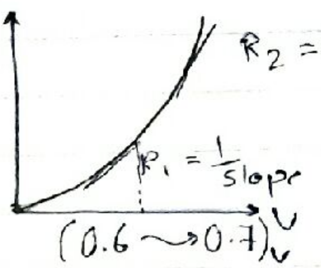


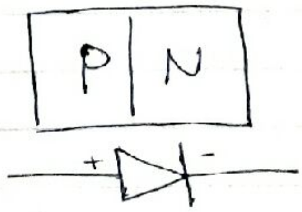
$$\text{error} = \frac{|\text{true} - \text{exp}|}{\text{true}} \times 100\%$$



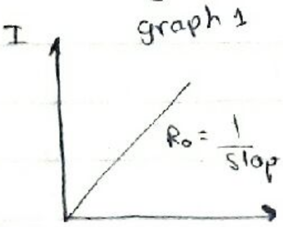
$$R = \frac{1}{\text{slope}}$$

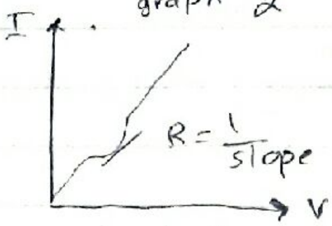
2 Diode :-





3 Light bulb

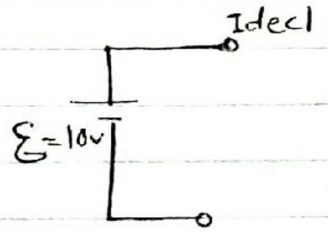


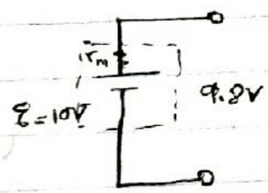


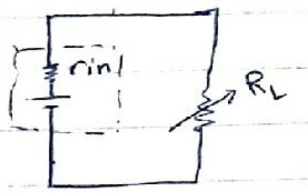
low currant — high Currant

graph 2 ← $\underbrace{R}_{} = \underbrace{R_o}_{\text{graph 1}} [1 + \underbrace{\alpha}_{4.5 \times 10^{-3}} (T - \underbrace{T_o}_{300\ k})]$

Exp2: Source Internal R, loading problem and Impedence matching.







$$I = \frac{\mathcal{E}}{(r_{in} + R_L)}$$

$$V_{R_L} = \underline{\frac{\mathcal{E}}{(r_{in} + R_L)} R_L}$$

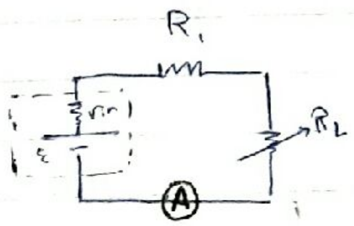
↳ ohm's law

$V = I R$

- if $r_{in} \ll R_L \Rightarrow V_{R_L} \sim \mathcal{E}$

- if $r_{in} \simeq R_L \Rightarrow V_{R_L} \sim \frac{\mathcal{E}}{2}$ « loading problem »

<u>slove</u> • By adding another resistanc



- $R_{in} = \overset{\to 1k\Omega}{R_1} + r_{in}$

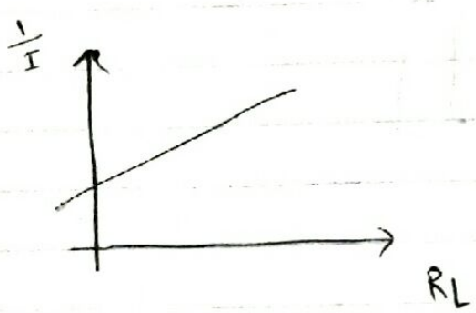
- $I = \frac{\mathcal{E}}{(R_L + R_{in})}$

$$\frac{1}{I} = \frac{R_L + R_{in}}{\mathcal{E}}$$

$$\frac{1}{I} = \frac{R_L}{\mathcal{E}} + \frac{R_{in}}{\mathcal{E}}$$

$$\downarrow \quad \downarrow \quad \downarrow$$

$$y = m x + b$$

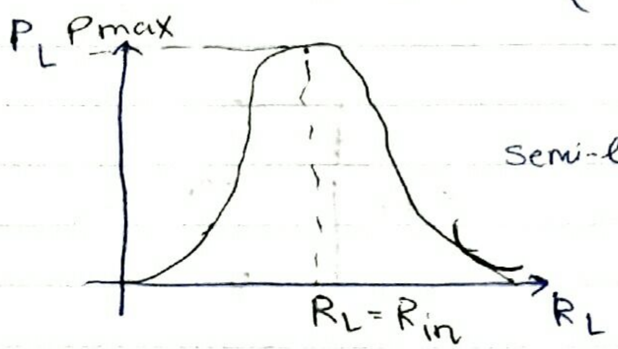


- slope $= \frac{1}{\mathcal{E} \to 10v}$

- y intercipt $= \frac{R_{in} \to \text{المطلوب!}}{\mathcal{E} \to \text{slope مقلوب}}$

• power $(R_L) = IV = I^2 R_L$

$$= \left(\frac{\mathcal{E}}{R_L + R_{in}}\right)^2 R_L$$



semi-log

$$P = \left(\frac{\mathcal{E}}{R_L + R_{in}}\right)^2 R_L$$

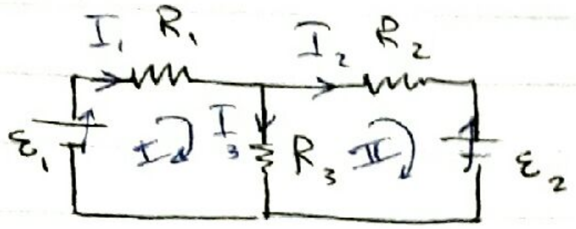
• must be in conclosion.

$$\frac{dP}{dR_L} = 0$$

power (maximum) when ⇒ $R_L = R_1 + r_{in}$

• errore $R_{in} = \frac{|R_{in\,th} - R_{in\,exp}|}{R_{in\,th}} \times 100\%$

Exp 3:



- $\varepsilon_1 = 10\ V$
- $\varepsilon_2 = 5\ V$
- $R_1 = 1\ K\Omega$, $R_2 = 2.2\ K\Omega$

$R_3 = 5.1\ K\Omega$

- Kirshoof's law
  - $\sum_{loop} V = 0$
  - $\sum_{node} I = 0$

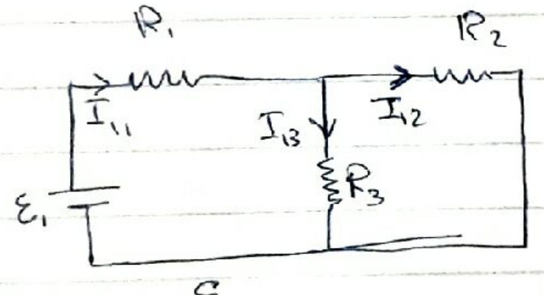
(I): $\varepsilon_1 - I_1R_1 - I_3R_3 = 0$ ------ ①

(II): $\varepsilon_2 + I_2R_2 - I_3R_3 = 0$ ------ ②

(III) $I_1 = I_2 + I_3$ ------ ③

Super position:-

→ kill ε_2



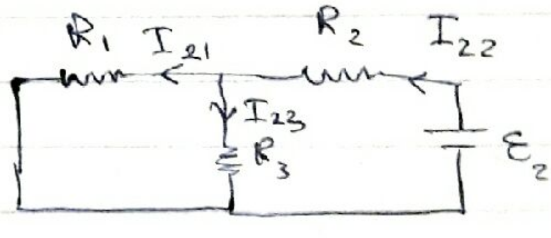
⊛ $I_{11} = \dfrac{\varepsilon_1}{R_1 + \dfrac{R_2R_3}{R_2+R_3}}$

⊛ $I_{13}R_3 = I_{12}R_2$

⊛ $I_{11} = I_{13} + I_{12}$

$I_{12} = I_{11} - I_{13}$

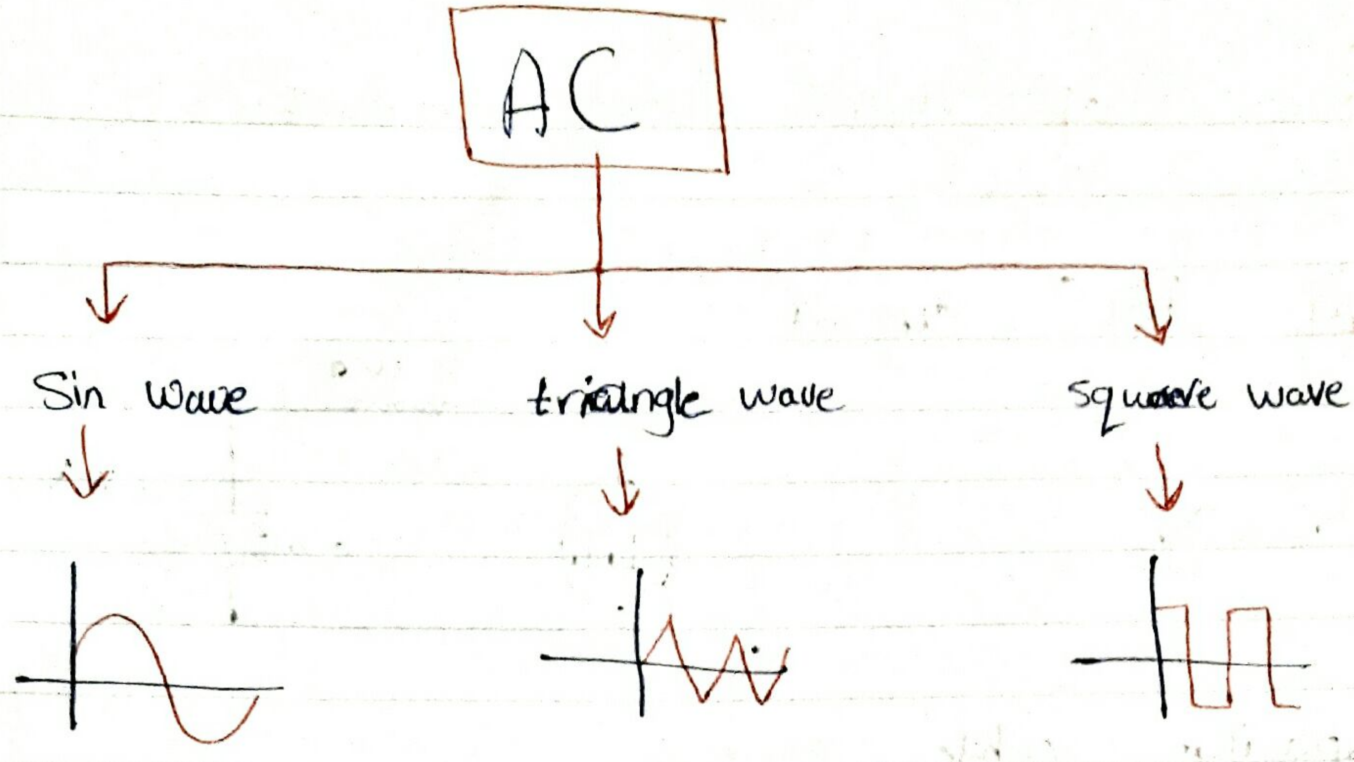
→ kill ε_1



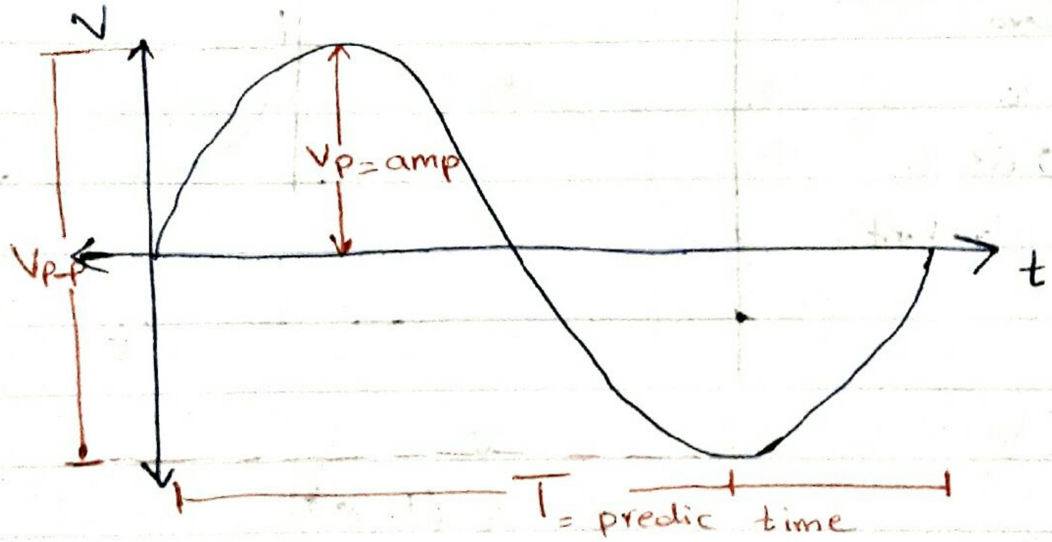
⊛ $I_{22} = \dfrac{\varepsilon_2}{R_2 + \dfrac{R_1R_3}{R_1+R_3}}$

⊛ $I_{23}R_3 = I_{21}R_1$

⊛ $I_{22} = I_{23} + I_{21}$



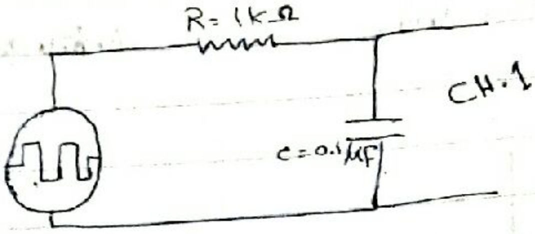
• Sin wave :-



. frequancy = $\frac{1}{T}$

Ex 6: Capacitors and Inductors

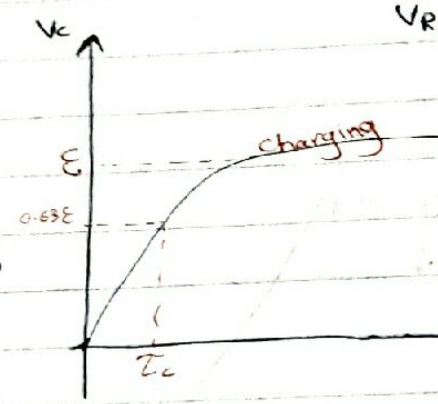
PART A — RC circuit:-

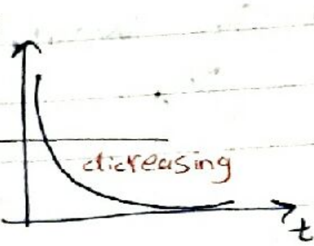


$\Rightarrow \mathcal{E} = V_R + V_c$

• The Capacitor's while Charging:-

$\Rightarrow V(t) = \mathcal{E}(1 - e^{-t/RC})$





• when $t = \text{zero} \Rightarrow \mathcal{E}(t) = \text{zero}$

• when $t = \infty \Rightarrow \mathcal{E}(t) = \mathcal{E}$

• when $t = RC \Rightarrow \mathcal{E}(t) = 0.63\,\mathcal{E}$

$t = RC = \tau_c \Rightarrow$ "time Constant"

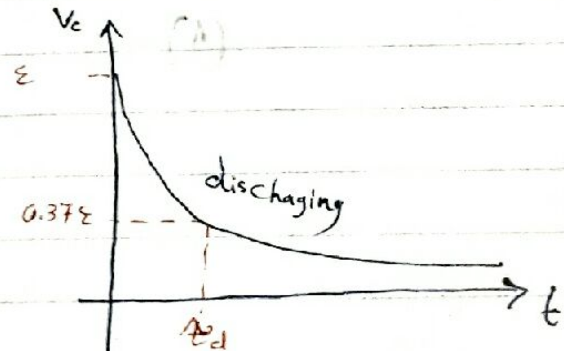
$\Rightarrow$ when $t = RC = \tau_c \Rightarrow V_R = \mathcal{E} - V_c$

$= \mathcal{E} - \mathcal{E}(1 - e^{-t/\tau})$

$= \mathcal{E}\, e^{-t/\tau}$ Volte

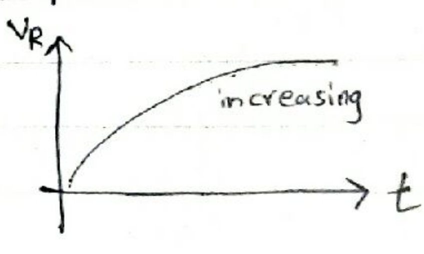
• The Capacitors while dis charging:-

$\Rightarrow V_c = \mathcal{E} e^{-t/\tau}$



• when $t = \tau_d \Rightarrow \mathcal{E}(t) = 0.37\,\mathcal{E}$

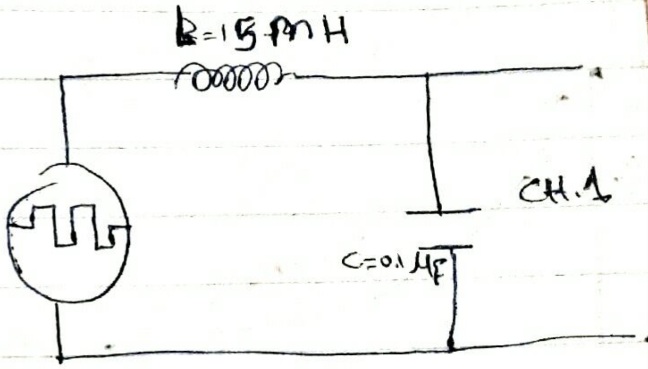
$\Rightarrow \tau = \dfrac{\tau_d + \tau_c}{2}$



PART C   LC circuit

$$\omega_0 = \frac{1}{\sqrt{LC}} = 2\pi f_0$$

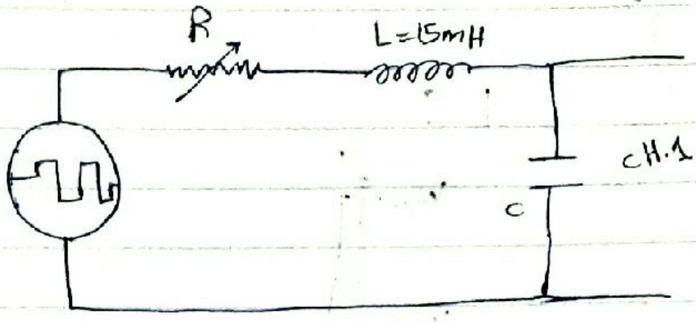
angular frequency



• f_0 = Resonance freq

• لحساب f_0 عملياً في الدارة المجاورة نقوم بزيادة التردد تدريجياً مما يترتب عليه زيادة الجهد ثم نتوقف فجأة ليعود للصفر << هنا تكون قيمة f_0 >>.

Exp 7 Damped Oscillations

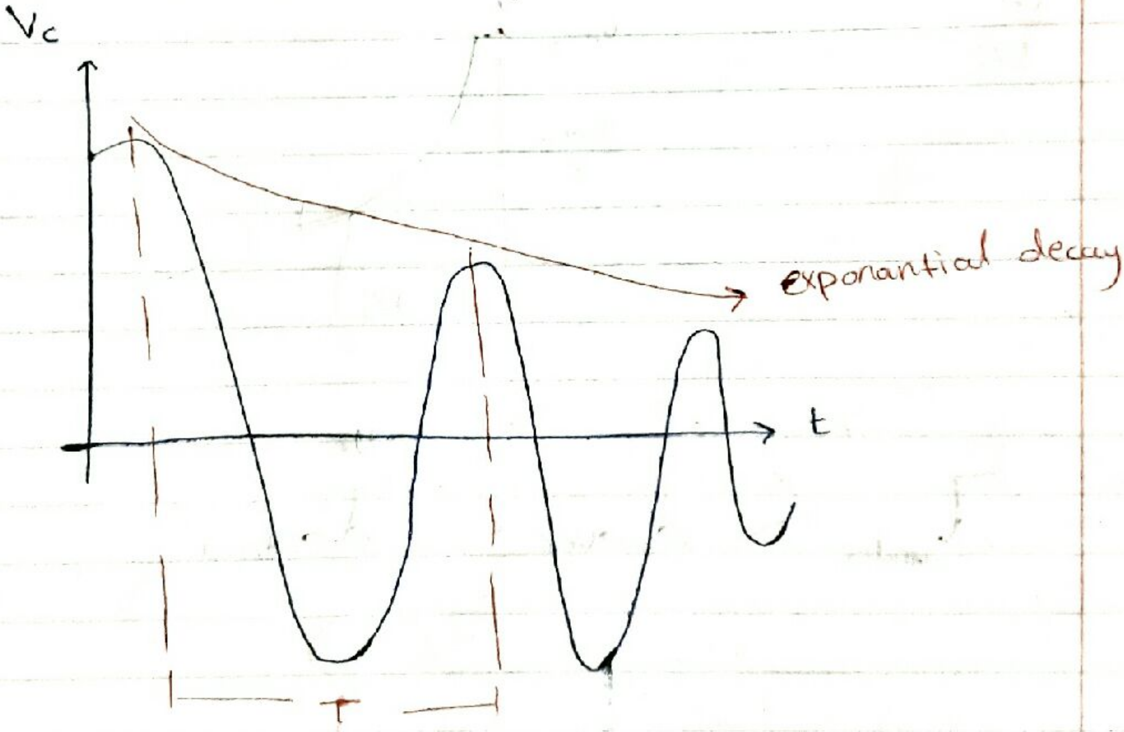


- $V_c(t) = A_1 e^{+\lambda t} + A_2 e^{-\lambda t}$

- $\lambda_{\pm} = \frac{-R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$

$\Rightarrow$ Case (I) : $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$, "under damping"

نوع المقاومة موجودة بهذه الحالة.



$\Rightarrow f_{exp} = \frac{1}{T} \Rightarrow \omega_{exp} = 2\pi f_{exp}$

$\Rightarrow \omega_{theoritical} = \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$

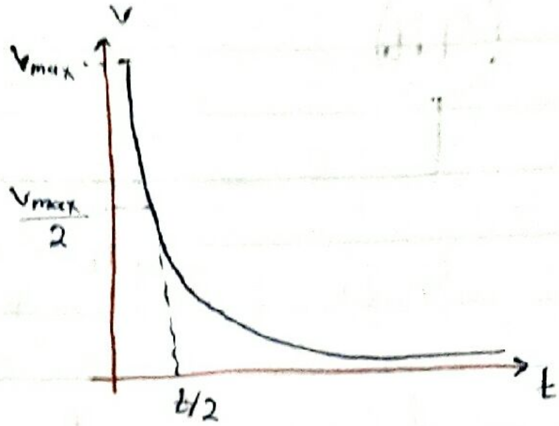
$\Rightarrow \lambda = \frac{\ln 2}{t_{1/2}} \Rightarrow t_{1/2} = \frac{2L \ln 2}{R_o}$

- $R_o = R$ under damping

Case (II): Critical damping :-

$$\left(\frac{R_c}{2L}\right)^2 = \frac{1}{LC}$$

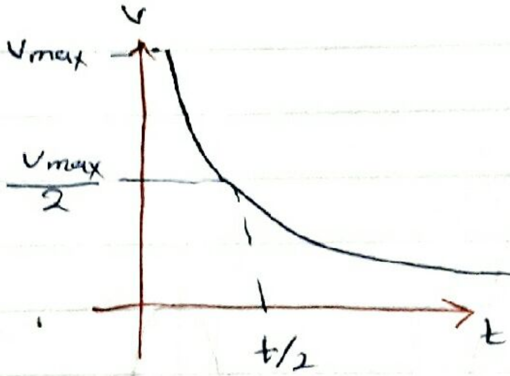
- $\lambda = \dfrac{\ln 2}{t/2}$ decay constant



- $R_{c\,exp} = R_0 + R_{gen}$

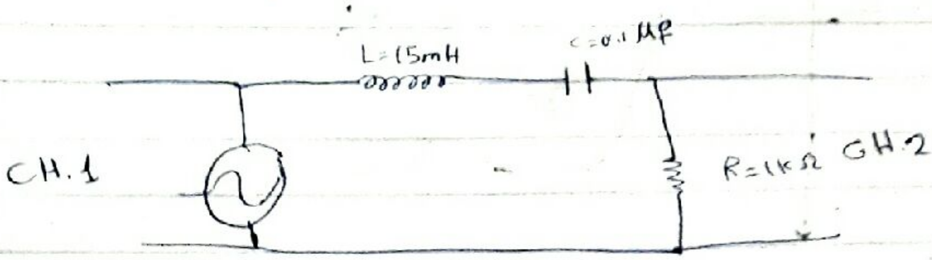
Case (III): Over damping : $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$

- $\lambda = \dfrac{\ln 2}{t/2}$



$$\lambda_{under} < \lambda_{over} < \lambda_{critical}$$

Ex 8 Impedence and reactance:



$\Rightarrow Z_R = R$ $\Rightarrow Z_c = \frac{-1}{wc} j$ متخيلي $\Rightarrow Z_L = wLj$

(inversaly) (directly)

$\Rightarrow Q_R = R$ $\Rightarrow Q_c = \frac{-1}{wc}$ $\Rightarrow Q_L = wL$

$$\Rightarrow Z_{eq} = R + \left(wL - \frac{1}{wc}\right) j$$

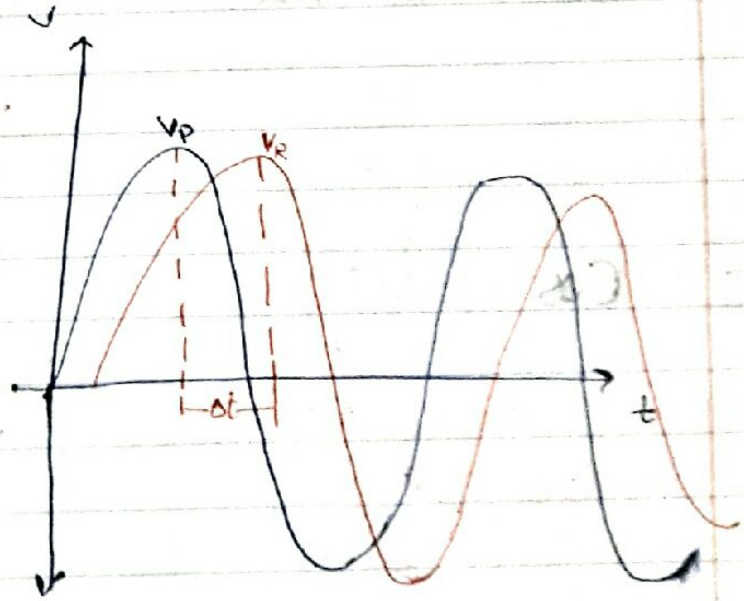
$$|Z_{eq}| = \sqrt{R^2 + \left(wL - \frac{1}{wc}\right)^2}$$

$$\Rightarrow I = \frac{\varepsilon}{\sqrt{R^2 + \left(wL - \frac{1}{wc}\right)^2}}$$

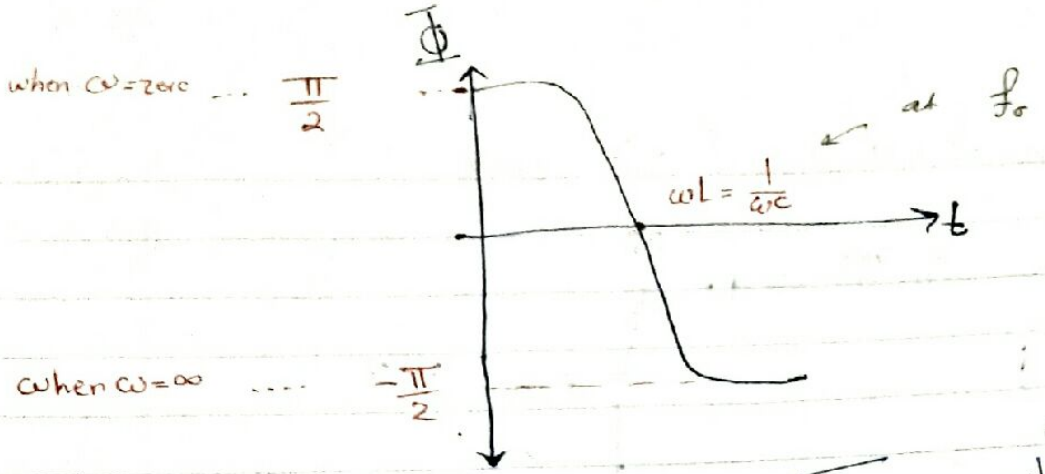
$$\Rightarrow \Phi = \tan^{-1}\left(\frac{+\frac{1}{wc} - wL}{R}\right)$$

- $\Phi = \omega \Delta t$
  $= 2\pi f \Delta t$

  phasa shift



(7)

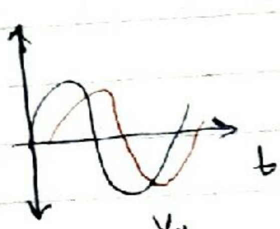


- $\omega L = \frac{1}{\omega C} \Rightarrow \omega_o = \sqrt{\frac{1}{LC}} \Rightarrow$ when $\Phi = zero$

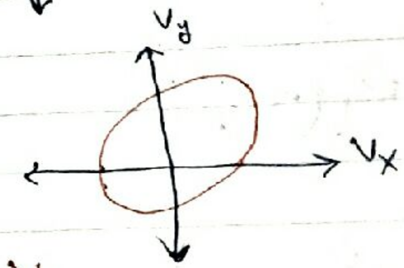
← الموجتان متطابقتان

← القيم بعد $\Phi = zero$ لـ Δt ← تكون سالبة لأن الموجتان تتغير موقعهما بالنسبة لبعضهما

→ Internal mode →



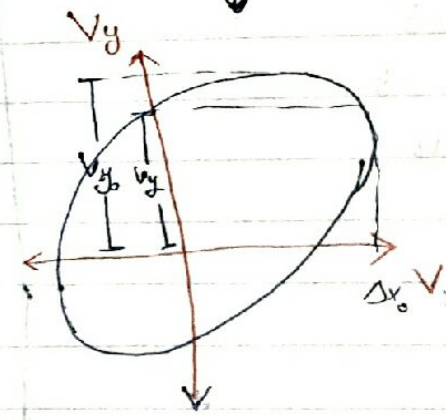
→ external mode

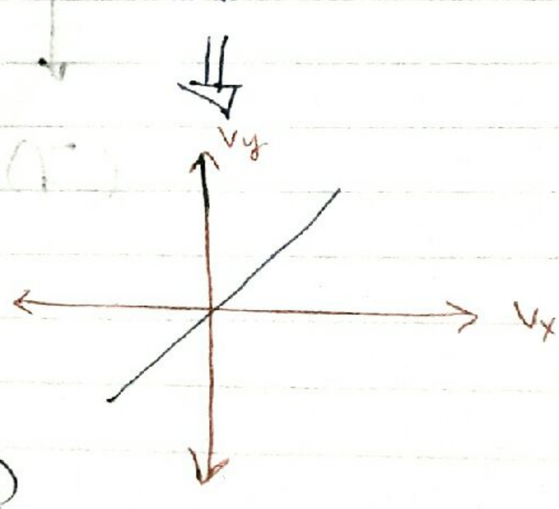


- In external mode

$\rightarrow \Phi = \cos^{-1}\left(\frac{V_{y_\bullet}}{V_{y_o}}\right)$

→ At f_o (Resonanc) the ellipes turn to a line.



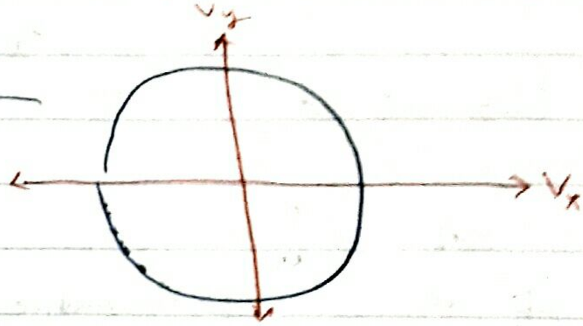


• At f resonance → L (تسبق) $R \rightarrow \frac{\pi}{2}$

R (تسبق) $C \rightarrow \frac{\pi}{2}$

• At external mode

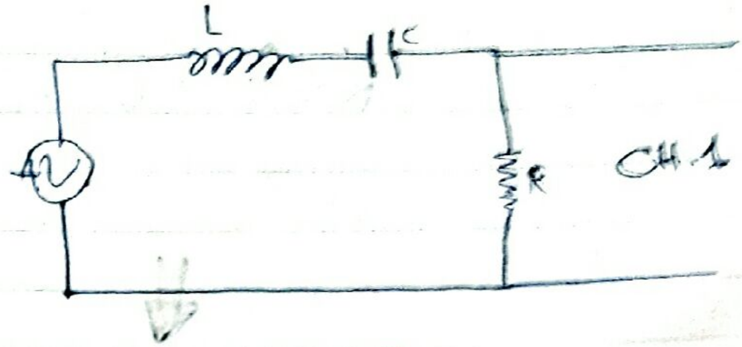
• the ellipes turn to circle.

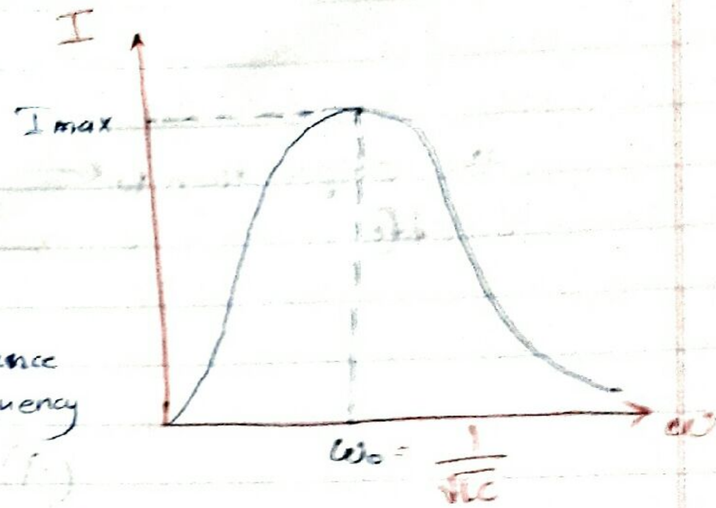


(9)

Exp 9 Resonance:

• $I = \dfrac{\mathcal{E}}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$





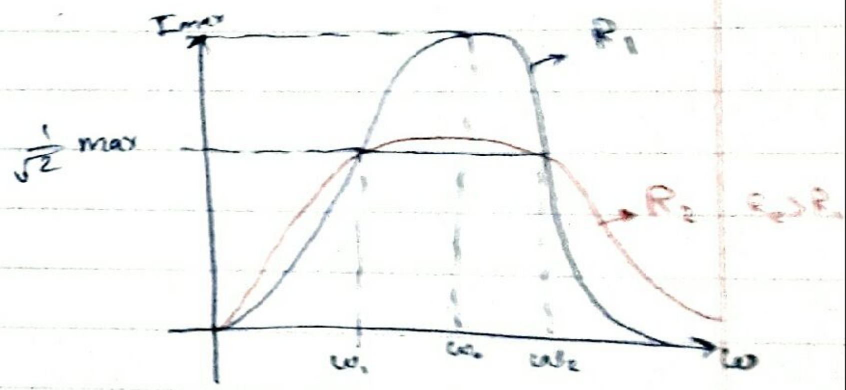
• when $\omega = 0 \Rightarrow I = 0$

• when $\omega = \infty \Rightarrow I \; 0$

• I_{max} when $\omega L = \frac{1}{\omega C}$

$\Rightarrow \omega_o = \frac{1}{\sqrt{LC}} \Rightarrow$ Resonance frequency

• Quality factor : يعبر عن حدة التيار



$\Rightarrow Q_{exp} = \frac{\omega_o}{\Delta\omega} = \frac{\omega_o}{\omega_2 - \omega_1}$

$\Rightarrow Q_{th} = \frac{1}{R_1}\sqrt{\frac{L}{C}}$

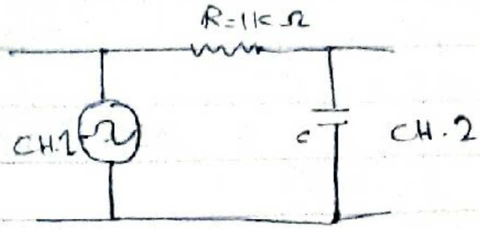
• ω_o للمقاومتين هي نفسها $\longrightarrow$ $\sqrt{\frac{1}{LC}}$ لأنها تعتمد

Ex 10 Filters

1 low-pass filters :-

$Z_R = R$, $Z_c = -\frac{1}{wc} j$

$\Rightarrow Z_{eq} = R - \frac{1}{wc} j$,



$\Rightarrow V_c = \frac{Z_c}{R+Z_c} \varepsilon = \frac{-\frac{1}{wc} j \, V_{in}}{R - \frac{1}{wc} j}$ ⇒ ضرب بالمرافق

$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{1}{1 + RCwj} \Longrightarrow \left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+(RCw)^2}}$

→ Atenuation factor (A)

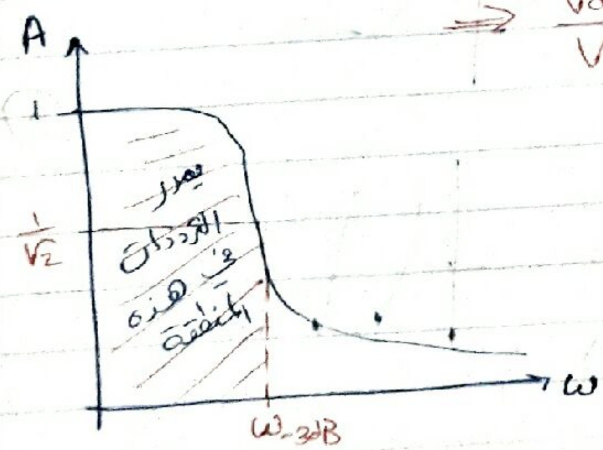
→ $A = \frac{1}{\sqrt{1+(Rwc)^2}}$

• $w_{-3dB} = \frac{1}{RC} \Longrightarrow R^2C^2 = \frac{1}{w^2_{-3dB}}$

$\Rightarrow A = \frac{1}{\sqrt{1+\left(\frac{w}{w_{-3dB}}\right)^2}}$

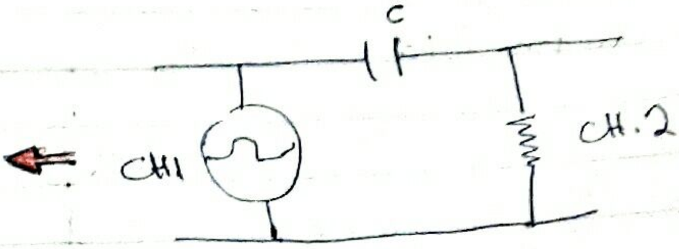
• when $W = w_{-3dB} \Rightarrow V_{out} = \frac{1}{\sqrt{2}} V_{in}$

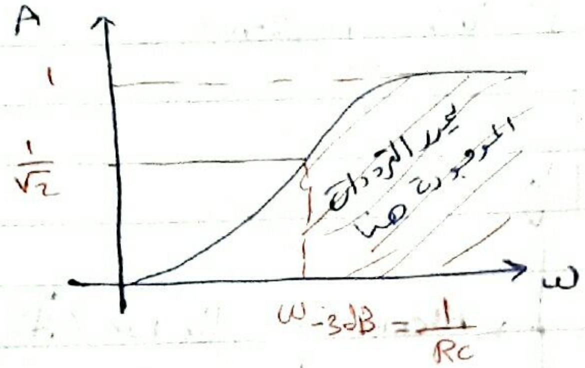
$\Longrightarrow \underbrace{\frac{V_{out}}{V_{in}}}_{A} = \frac{1}{\sqrt{2}}$, $\frac{1}{RC} = w_{-3dB}$



[2] high pass filters

$$A = \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_{-3dB}}\right)^2}}$$

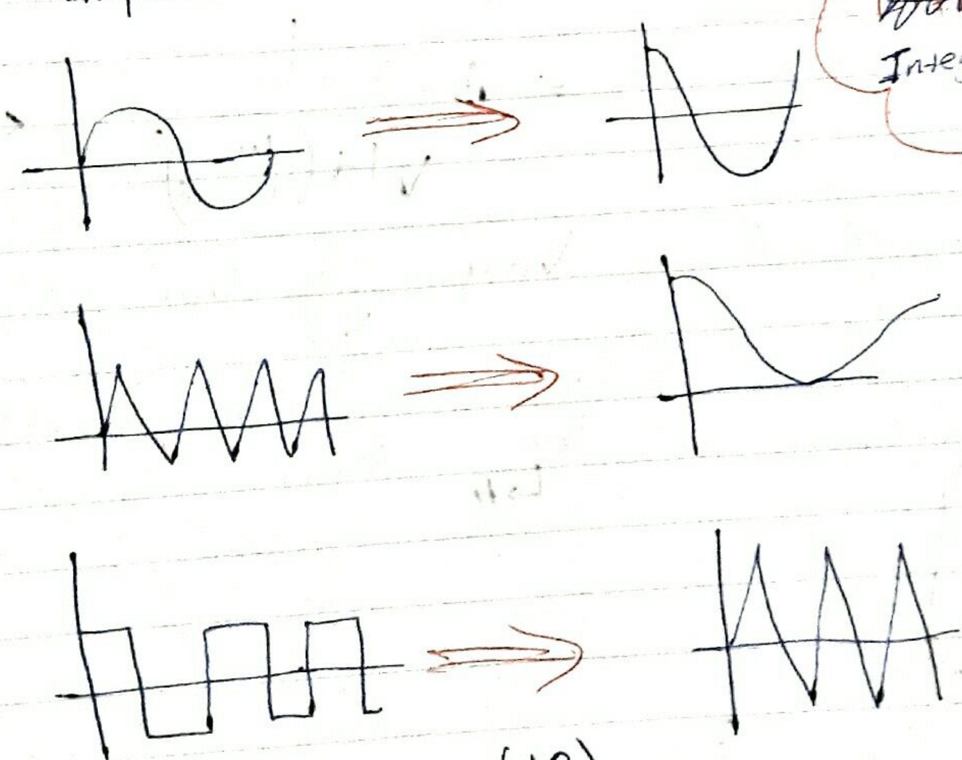




- low pass at high frequency $\simeq$ 70KH

input ⟹ output

work as a ~~Differentiators~~ Integrators



• high pass at low frequency ≃ 200 HZ

input → out put

work as an Differentiators