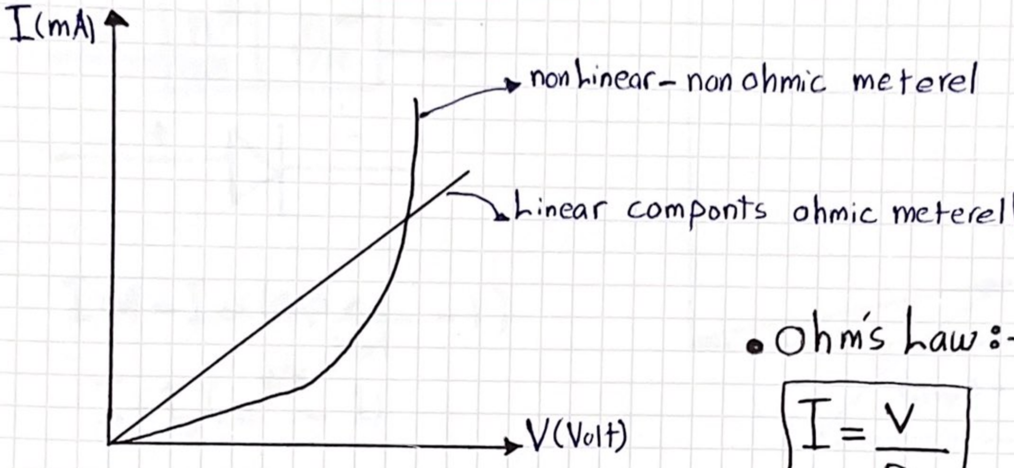
Experment # 1

→ Linear and non Linear circet componts ←

IV - charastrice cureV:



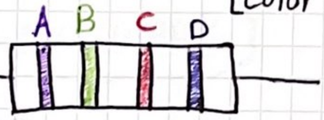
$\boxed{V = I R}$

• Ohm's Law :-

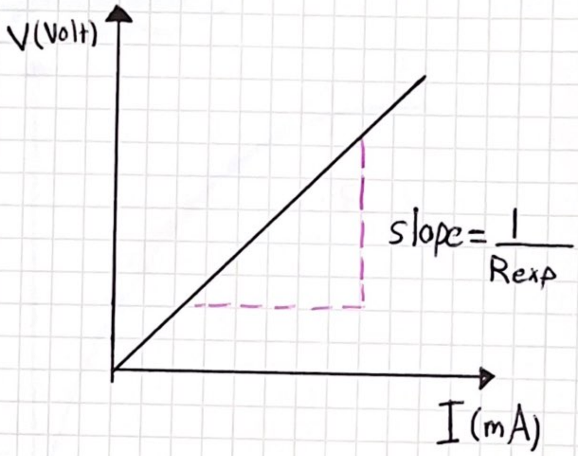
$$\boxed{I = \frac{V}{R}}$$

carbon Resistor:-

R_{theo} :- كيف نحسب قيمة المقاومة عن طريق [color code]

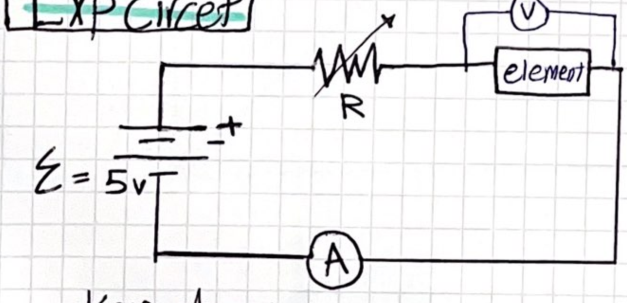


$$\left[(AB * 10^{c}) \pm (D * AB * 10^{c})\right]$$



$slope = \frac{1}{R_{exp}}$

Exp circet



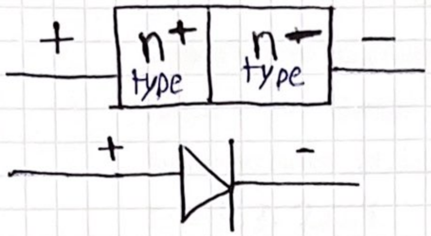
$\mathcal{E} = 5v$

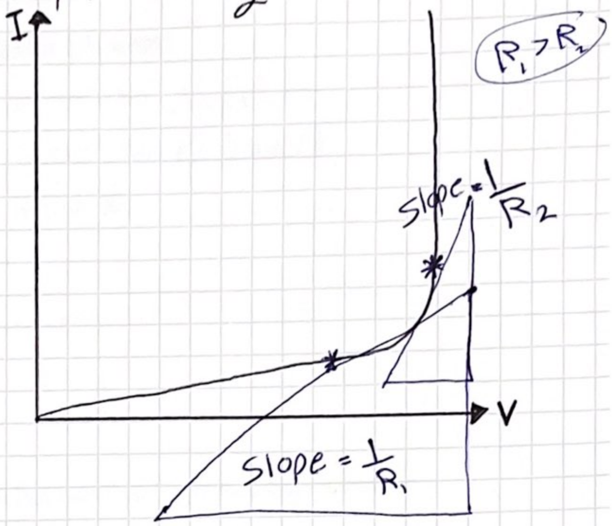
→ Keep changing the value of R to become (0.1, 0.4 ....) and meaure I then draw I vs V by Exule or by hand.

(V) Volt	0.1	0.4	0.8	1.2	1.5	...	...
(I) mA	...	—	...	—	...	...	...

Linear and nonlinear cirut componts

2 Diode:- Allow current to pass through in one Direction





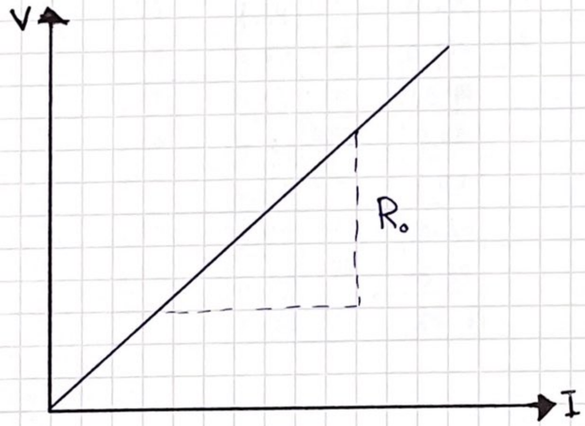
$$I(V) = I\alpha(\exp\frac{ex}{Kot} - 1)$$

$$I = I_0(e^{V/K} - 1)$$

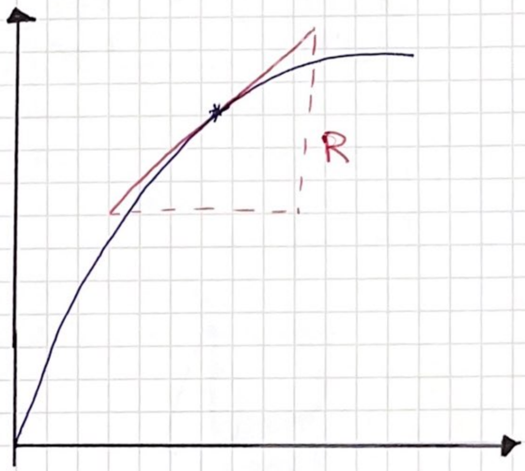
3 Light bulb:- Tangsten wire

Law curent

High curent



Linear



Non-Linear

$$\longrightarrow R = R_0\left[1 + \alpha(T - T_0)\right]$$

$\alpha_{\text{Tengsten}} = (4.5\times10^{-3})K^{-1}$

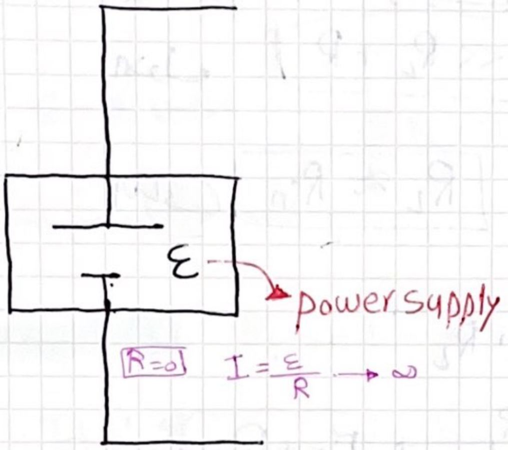
T_0 = room Temp

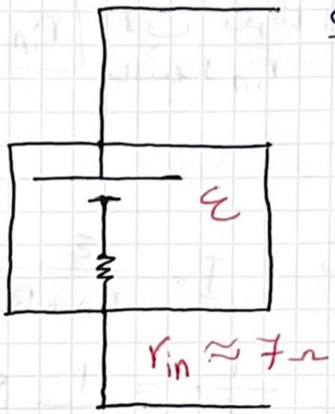
α = Temp coefficient of resistity

R_0 = the resistance at temp

Exp#2: Source Internal Resistance. Loding Problem and circuit Impedance Matching

Sonrce interred Resistance.





$V_{ab} \approx \varepsilon$

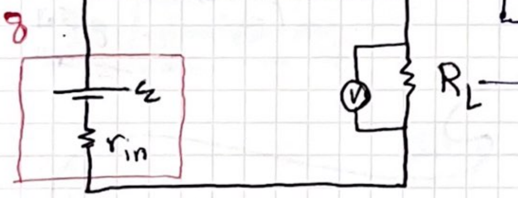
Ided power supply Ideal Buttery

بطارية مثالية

Red power supply Real Battary

Loding proflem:

$$\boxed{R_L \geqslant 10\, r_{in}}$$ to avoid Loading Source



R_L → Load: Load Resistance

حمل أجهزة ممكن يكون
مصباح ممكن يكون تلفزيون

$\boxed{{}_{R_1} V = IR}$

$$V_L = \frac{R_L}{(r_{in} + R_L)}\varepsilon$$

$$I = \frac{\varepsilon}{r_{in} + R_L}$$

$$V_L = \frac{1}{\frac{r_{in}}{R_L} + 1} \rightarrow \begin{array}{l} r_{in} \approx R_L \rightarrow \cancel{\varepsilon} \\ r_{in} \leqslant R_L \end{array}$$

$$\boxed{V_L \approx \frac{\varepsilon}{2}}$$

Power:-

$$P = I^2 R_L$$

$$* \; P = \left(\frac{\varepsilon}{r_{in} + R_L}\right)^2 R_L \qquad * \; P = \frac{V^2}{R_L} \quad V(R_L)$$

Maximum Power

$$\frac{\partial P}{\partial P_L} = 0 \longrightarrow R_L = r_{in}$$

Power(Max) $R_L = r_{in}$

Voltage(Pell) $R_L \geqslant 10 r_{in}$

هون بتحقق عنا impdance matching

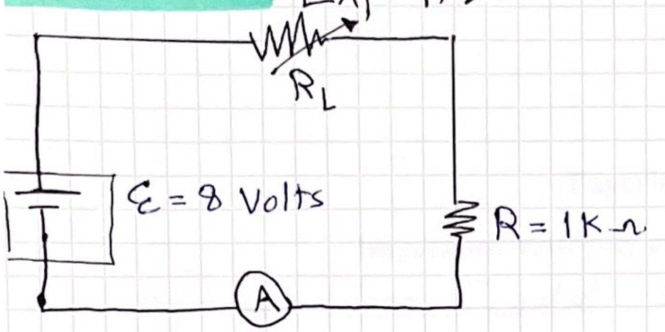
Impedance matching:

لما تكون المشتقة تساوي صفر
بحصل على اعلى قيمة لـ power
نطلع عنا $\boxed{R_L = r_{in}}$

بس عشان اتخلص من مشكلة انه لازم يكونوا عندي $R_L \geqslant 10 r_{in}$
ضفت R واعتبرتها موجودة من ضمن البطارية
يعني ركاني يجي

$$R_L = R + r_{in}$$

Exp #2



→ $\varepsilon_{exp} = \frac{1}{slope}$

→ $R_{in} = y\text{-int} \times \varepsilon_{exp}$

Slope $= \frac{1}{\varepsilon}$

Graph 1

$R_L = 0.1 \rightarrow 1K\Omega$ فقط جدول نوخذ

$$I = \frac{\varepsilon}{\underbrace{R + r_{in}}_{R_{in}} + R_L} = \frac{\varepsilon}{R_{in} + R_L}$$

$$\underbrace{\frac{1}{I}}_{y\text{-axis}} = \frac{1}{\varepsilon_{exp}} \underbrace{R_L}_{x\text{-axis}} + \frac{R_{in}}{\varepsilon_{exp}} \rightarrow R + r_{in}$$

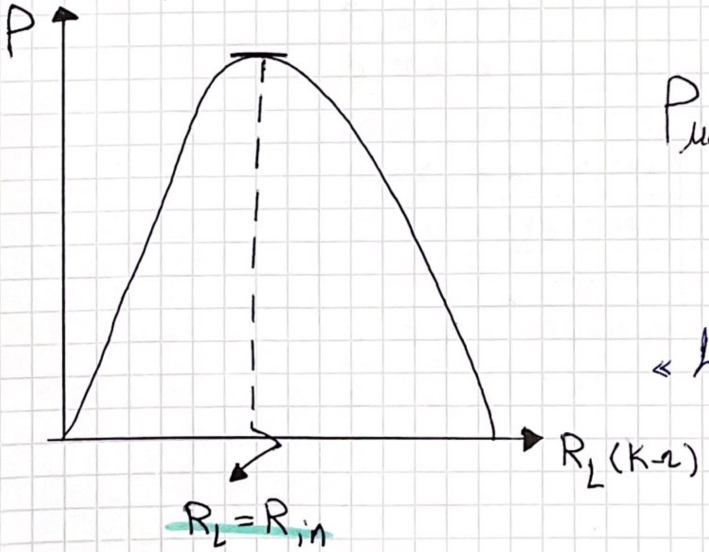
$\boxed{\frac{1}{I} \text{ vs } R_L}$

[1] slope $= \frac{1}{\varepsilon_{exp}}$ Straight line with slope $= \frac{1}{\varepsilon}$

[2] y-intecept $= \frac{R_{in}}{\varepsilon_{exp}}$ y-intercept $= \frac{R + r_{in}}{\varepsilon}$

Graph 2

P vs R_L $(0.1 \rightarrow 60 K\Omega)$ كلهم يعني

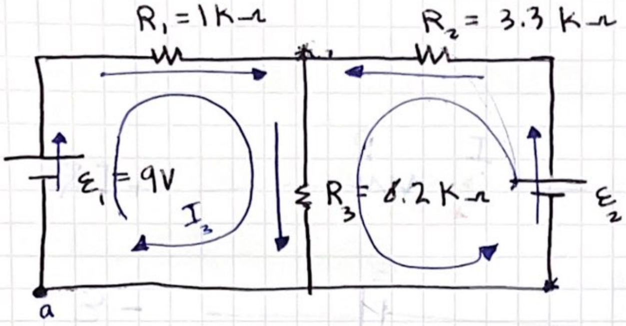


P_{max} at $R_L = R_{in}$

$R_{in} =$ ......

« Log axis »

Exp #3: Kirchhoffs Laws and superpostion principle



Kirchheffs 2^{and} law $\sum_{j=0}^{N} V_i = 0$

① ② ③ →

$I_1 =$ ..... mA
$I_2 =$ ..... mA
$I_3 =$ ..... mA

1^{st} Law: $\sum I_{(Junfine)} = 0$

$$\boxed{\sum I_{in} = \sum I_{out}}$$

$I_1 + I_2 = I_3 \longrightarrow$ ①

Loop 1

$\varepsilon_1 - I_1 R_1 - I_3 R_3 = 0 \longrightarrow$ ②

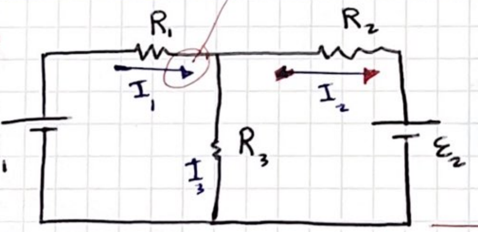
Loop 2

$\varepsilon_2 - I_2 R_2 - I_3 R_3 = 0 \longrightarrow$ ③

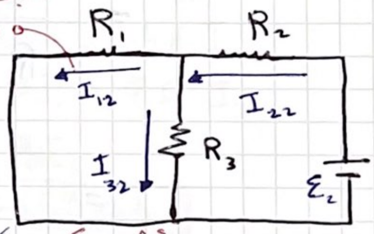
اتجاه التيار هيك لانو جاي من ε_1

SPP

كبر بوزيشن برنسبل



اتجاه التيار هيك لانو جاي من جهة ε_2



بدي اشوف تأثير ε_2 على المقاومات

$I_{11} - I_{12} = I_1$

التيار لي جاي من ε_1 على I_1

$I_{22} - I_{21} = I_2$

التيار لي جاي من ε_2 على I_2

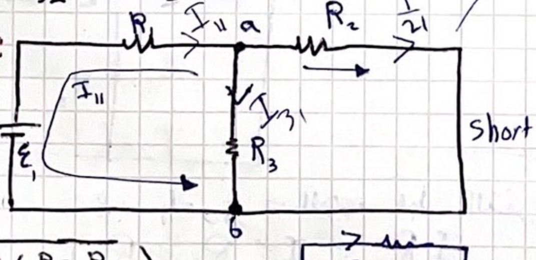
$I_{31} + I_{32} = I_3$

التيار لي جاي من ε_1 على I_3

نفس الاتجاه جمع
عكس الاتجاه طرح

+

بدي اشوف تأثير ε_1 على المقاومات



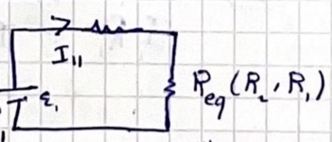
للتأكيد من القيم

$I_1 = 1.77 mA$

$I_2 = 0.66 mA$

$I_3 = 1.20 mA$

$$I_{11} = \frac{\varepsilon_1}{R_1 + \left(\frac{R_2 R_3}{R_2 + R_3}\right)}$$



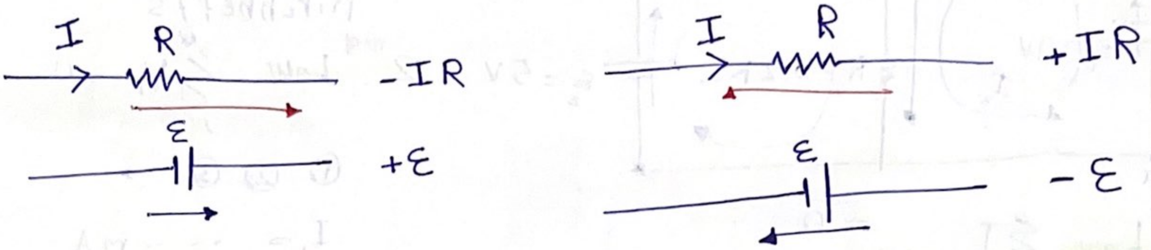
$V_{ab} = I_{21} R_2 = I_{31} R_3 = \varepsilon_1 I_{11} R_1$

انت المقاومة
[illegible]

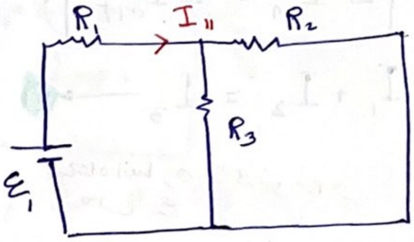
$$\boxed{I_{21} = \frac{V_{ab}}{R_2}}, \boxed{I_{31} = \frac{V_{ab}}{R_3}}$$

بعض القواعد لايجاد التيارات

Some Rules:



finding I_1 :-



$R_2 // R_3$

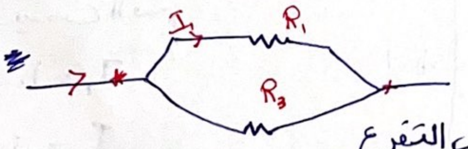
$$I_{11} = \frac{\varepsilon_1}{R_1 + R_2 // R_3}$$

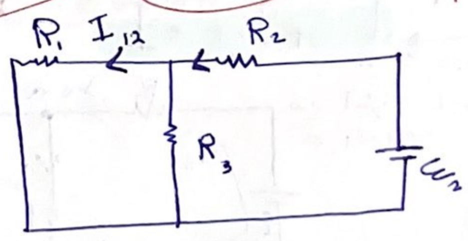
$$= \frac{\varepsilon_1}{R_1 + \frac{R_2 R_3}{R_2 + R_3}}$$

$$= \frac{12}{1 + \frac{3.3 * 6.2}{3.3 + 6.3}}$$

$$= 3.8 \, mA \; (\longrightarrow)$$

$$I = \frac{\varepsilon_2}{R_2 + R_1 // R_3}$$





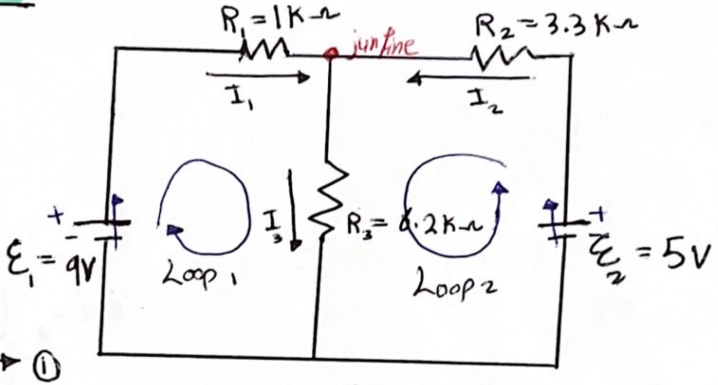
جهد الفرع = الجهد قبل التفرع

$$I_1 R_1 = I(\underbrace{R_1 // R_3}_{Req})$$

ExP 3:-

Kirchhoffs Laws and superpostion principle

1) Kirchhoff's Laws:



→ first Law:

$$\sum I_{junction} = 0$$

$$\sum I_{in} = \sum I_{out}$$

$$I_1 + I_2 = I_3 \longrightarrow ①$$

→ Second Law:

$$\sum_{i=0}^{n} V_i = 0$$

from Loop 1

$$\mathcal{E}_1 - I_1R_1 - I_3R_3 = 0$$

$$\mathcal{E}_1 = I_1R_1 + I_3R_3 \longrightarrow ②$$

$$9 = I_1 + 6.2 I_3$$

from Loop 2

$$\mathcal{E}_2 - I_2R_2 - I_3R_3 = 0 \longrightarrow ③$$

$$\mathcal{E}_2 = \underline{I_2}R_2 + I_3R_3$$

من المعادلة الاولى

$$\mathcal{E}_2 = (I_3 - I_1)R_2 + I_3R_3$$

$$= \underline{I_3}R_2 - I_1R_2 + \underline{I_3}R_3$$

$$\mathcal{E}_2 = I_3(R_2 + R_3) - I_1 R_2$$

$$5 = I_3(3.3 + 6.2) - 3.3 I_1$$

eq 3 + eq 2

$$\left[9 = I_1 + 6.2 I_3\right] \times 3.3$$

$$29.7 = \cancel{3.3I_1} + 20.46 I_3$$

$$+\ 5 = \cancel{-3.3I_1} + 9.5 I_3$$

$$34.7 = 29.96 I_3$$

$$\boxed{I_3 = 1.158\,mA}$$

$$9 = I_1 + 6.2(1.158)$$

$$\boxed{I_1 = 1.819\,mA}$$

$$I_1 + I_2 = I_3$$

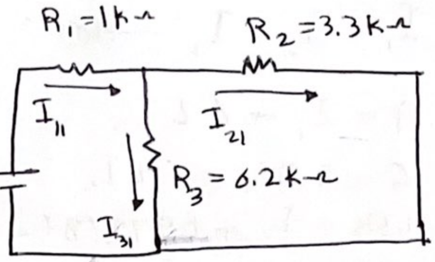
$$I_2 = I_3 - I_1$$

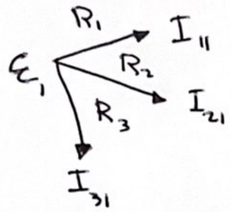
$$= 1.158 - 1.819$$

$$\boxed{I_2 = -0.661\,mA}$$

2) Superposition principle:-

A) connect the circuit shown





$$I_{11} = \frac{\varepsilon_1}{R_1 + \left(\frac{R_2 R_3}{R_2 R_3}\right)}$$

$$= \frac{9}{1 + \left(\frac{3.3 \times 6.2}{3.3 + 6.2}\right)} \quad 2.153$$

$$= \frac{9}{3.15}$$

$$\boxed{I_{11} = 2.8571 mA}$$

$\longrightarrow I_{21} R_2 = I_{31} R_3 = I_{11} R_{23}$

$3.3 I_{21} = 6.2 I_{31} = 2.85 \times 2.153$

$I_{21} = \frac{6.136}{3.3} = 1.859 mA$

$I_{31} = \frac{6.136}{6.2} = 0.9896mA$

$V = \cancel{I_{11} R_1} = I_{31} R_3 = I_{21} R_2$ v

$V = 2.85(1)$

$V = 2.85$

$V = I_{31} R_3$

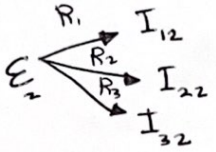
$I_{31} = \frac{V}{R_3}$

$V = I_{21} R_2$

$I_{21} = \frac{V}{R_2}$

2) superposition principle

B) connect the circuit shown



$$I_{22} = \frac{\mathcal{E}_2}{R_2 + \left(\frac{R_1 R_3}{R_1 + R_3}\right)}$$

$$= \frac{5}{3.3 + \underbrace{\left(\frac{1\times 6.2}{1+6.2}\right)}_{\to 0.86}}$$

$$= \frac{5}{4.16}$$

$$\boxed{I_{22} = 1.20\,mA}$$

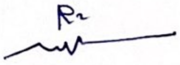
$$I_{22} R_{13} = I_{32} R_3 = I_{12} R_1$$

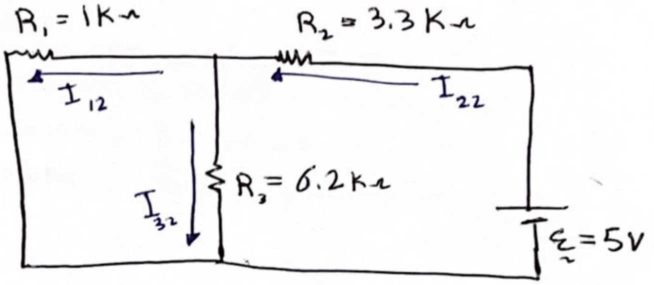
$$1.20 \times 0.86 = I_{32} \times 6.2 = I_{12} \times 1$$

$$I_{32} = \frac{1.032}{6.2}$$

$$\boxed{I_{32} = 0.1664\,mA}$$

$$\boxed{I_{12} = 1.032\,mA}$$





final step

Find the current using SPP

$* \; I_1 = I_{11} - I_{12}$

$$= 2.853 - 1.032$$

$$\boxed{I_1 = 1.821\,mA}$$

$* \; I_2 = I_{22} - I_{21}$

$$= 1.20 - 1.859$$

$$\boxed{I_2 = -0.659\,mA}$$

$* \; I_3 = I_{31} + I_{32}$

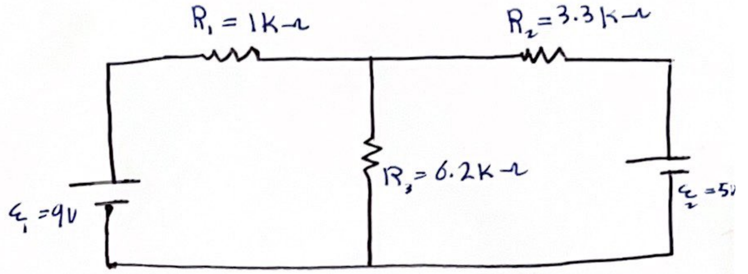
$$= 0.9896 + 0.1664$$

$$\boxed{I_3 = 1.156\,mA}$$

EXP#4

Thevenin and Norton technique

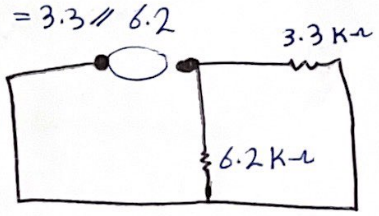
① when $I_1 = I_L$



- $R_1 = 1K\Omega$
- $R_2 = 3.3K\Omega$
- $R_3 = 6.2K\Omega$
- $\varepsilon_1 = 9V$
- $\varepsilon_2 = 5V$

→ Kill our V sources to find R_{th}

$R_{th} = 3.3 \parallel 6.2$

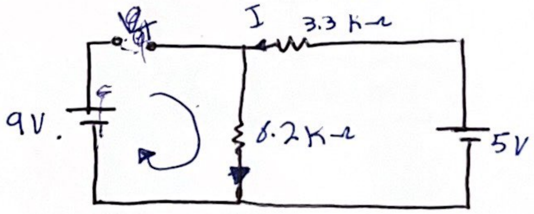


$\boxed{1}$ Req ⟶ $Req = \dfrac{R_2 * R_3}{R_2 + R_3}$

$$= \frac{3.3 * 6.2}{3.3 + 6.2} = 2.153\ K\Omega$$

to find V_{th}, Remove R_L and return ε_1 and ε_2 to the circuit

$\boxed{2}$ ε_{th} :-



By Karchoff:-

$$\varepsilon_1 - \varepsilon_{eq} - I_{eq} R_3 = 0$$

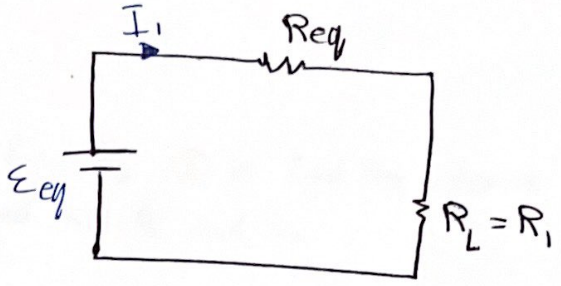
$$9 - \varepsilon_{eq} - 0.52(6.2) = 0$$

$$\varepsilon_{eq} = 5.736\ V$$

$\boxed{3}$ $I_{eq} = \dfrac{\varepsilon_2}{R_2 + R_3} = \dfrac{5}{3.3 + 6.2}$

$= 0.52mA$

constrect Thevinin circut:-



$$I_1 = \frac{\mathcal{E}_{eq}}{R_{eq} + R_1}$$

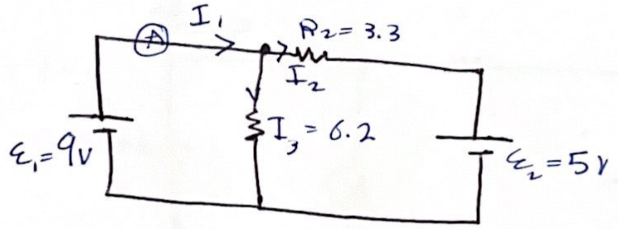
$$= \frac{5.776}{2.153 + 1}$$

$$\boxed{I_1 = 1.83\,mA}$$

---

constrect Norton circuit:

$R_{eq} = 2.153\,K\Omega$ → Thevinin نفس طريقة



I_{eq} $\quad I_1 = I_2 + I_3$

$$9 - 6.2 I_3 = 0$$

$$\boxed{I_3 = 1.4516\,mA}$$

$$9 - 3.3 I_2 - 5 = 0$$

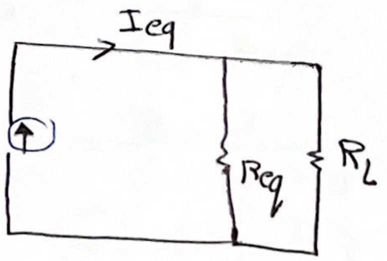
$$\frac{4}{3.3} = I_2$$

$$\boxed{I_2 = 1.21\,mA}$$

$$I_1 = I_{eq} = I_3 + I_2$$

$$\boxed{= 2.8816\,mA}$$

I جهد الفرع = جهد الفرع كامل



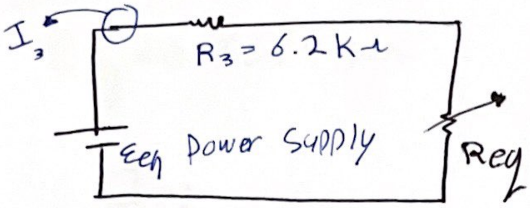
$$I_{eq}\,(R_{eq} \parallel R_L) = I\,R_L$$

$$2.8816\left(\frac{2.153}{3.153}\right) = I * 1k\Omega$$

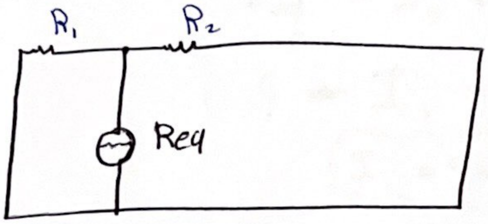
$$\boxed{I = 1.8174\,mA}$$

when $I_3 = I_L$

Thevenin $R_L = R_3$



- to find I_3 Ⓐ to find Req , Remove R_L and kill ε_1 and ε_2



$$Req = \frac{R_1 * R_2}{R_1 + R_2}$$

theory

$$= \frac{1 * 3.3}{1 + 3.3}$$

$$\boxed{Req = 0.7674\,K\Omega}$$

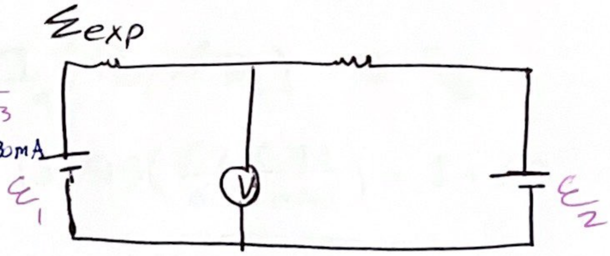
- to find ε , Remove R_L and return ε_1 and ε_2

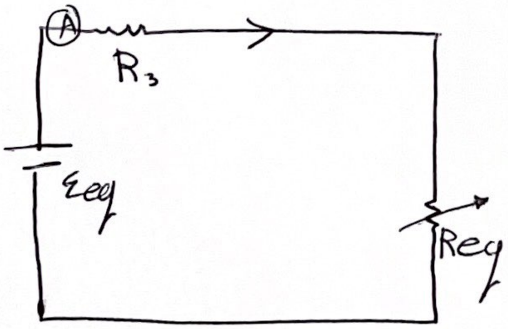
ε_{theory} $$I' = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_2} = \frac{9-5}{1+3.3} = 0.930\,mA$$

$$\varepsilon_{eq} = \varepsilon_1 - I'R_1$$

$$= 9 - (0.930) \times 1$$

$$\boxed{= 8.07 \text{ Volt}}$$



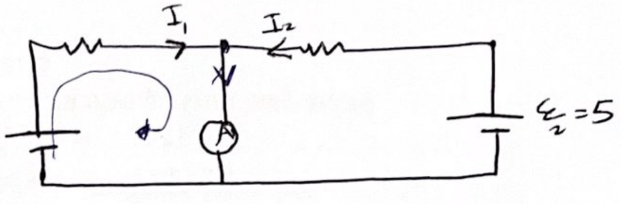


$$I_3 = \frac{\varepsilon_{eq}}{R_3 + Req}$$

$$= \frac{8.07}{6.2 + 0.767}$$

$$\boxed{= 1.1582\,mA}$$

at Nortorn



$R_{eq} = 0.7874\,k\Omega$

I_{eq}

$I_{eq} = I_3 + I_2$

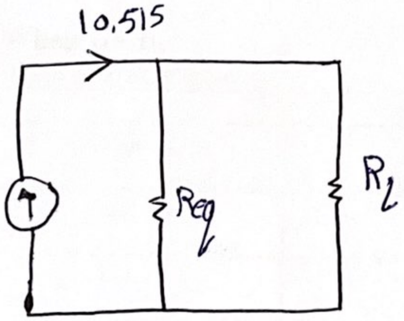
$9 - I_1 = 0$

$\boxed{I_1 = 9mA}$

$5 + 3.3 I_2 = 0$

$\boxed{I_2 = -1.515mA}$

$\boxed{I_{eq} = I_3 = 10.515mA}$



$I_{eq}(Req // R_L) = I\,R_L$

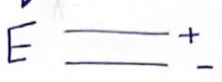
$10.515\left(\frac{6.2 * 0.76}{6.2 + 0.76}\right) = I * 6.2$

$\boxed{I = 1.158mA}$

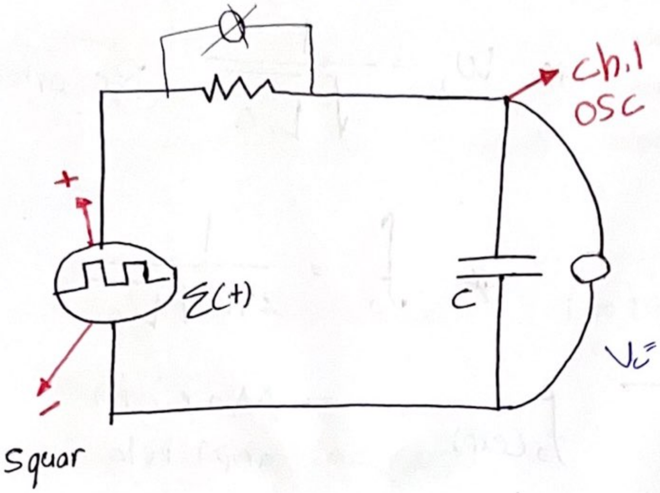
Experement 5 + 6 Capactor and Inductor

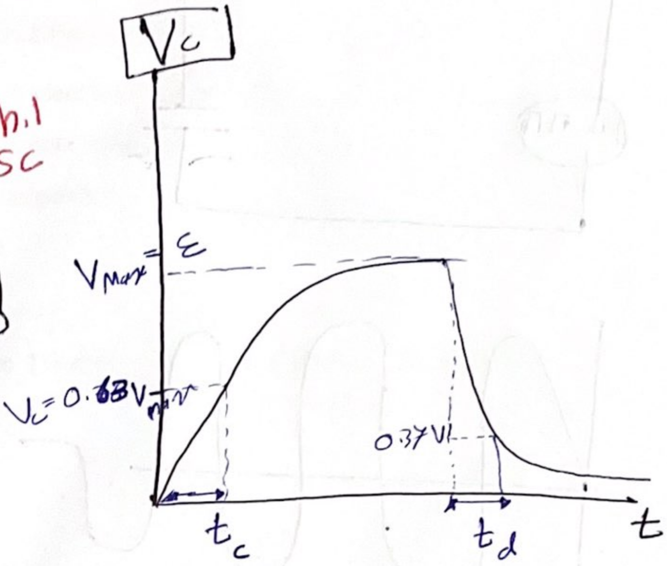
4 5 — 10

موسع محث



RC - circuit



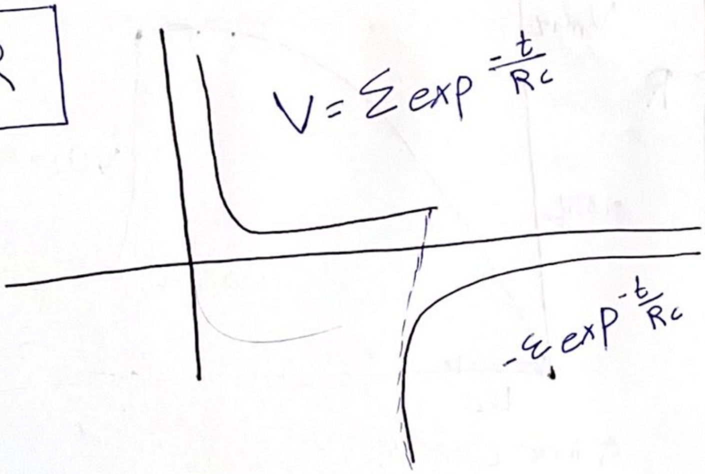


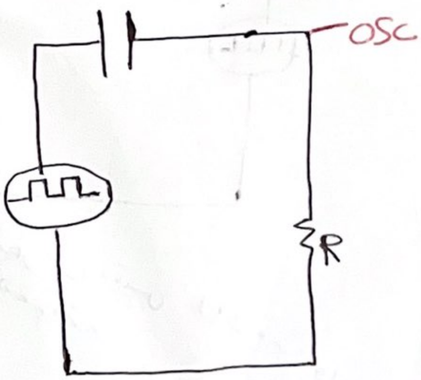
t → time constant

$$\boxed{\tau_{theo} = RC} = \text{seconds}$$

$$\boxed{\tau_{exp} = \frac{t_c + t_d}{2}}$$

VR

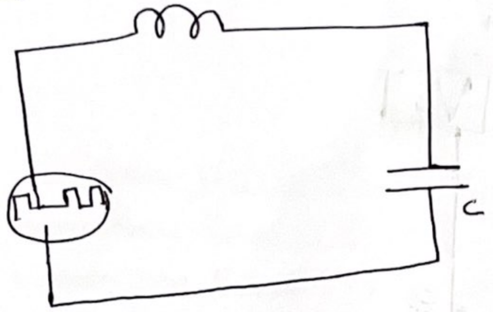


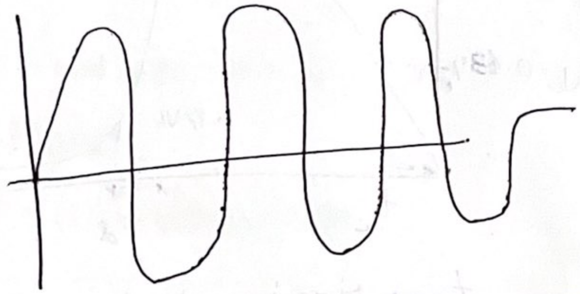


بدلت مكان R و C

LC-circuit

L مكان المقاومة مكثف





$* \; V_c = V_c \cos(\omega t + \emptyset)$

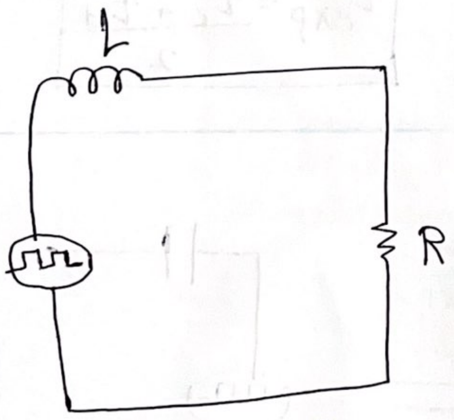
$* \; V_{c_0}$ = Amplitute

$* \; \omega_0 = \frac{1}{\sqrt{LC}}$ Resonace

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

f_0 (exp) → Maximum amplitele

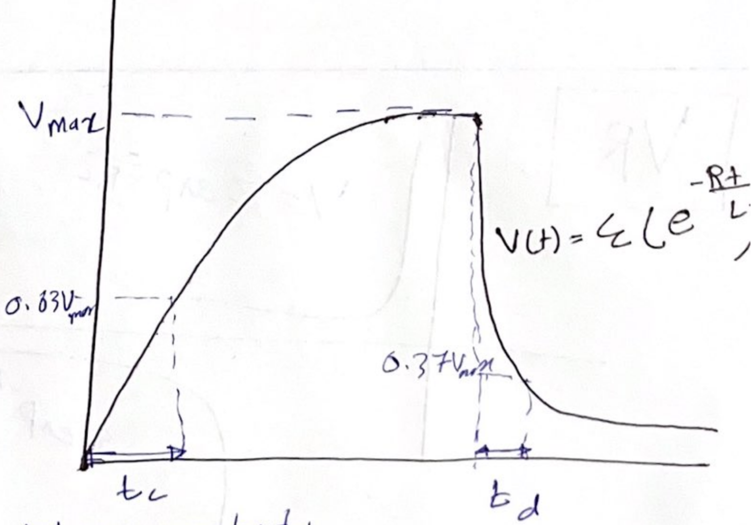
RL- circut



العنصر يلي بقيس عليه الاشارة صوابه للفولتية

V_R

charging $V(t) = \varepsilon(1 - e^{-\frac{Rt}{L}})$



$V(t) = \varepsilon(e^{-\frac{Rt}{L}})$

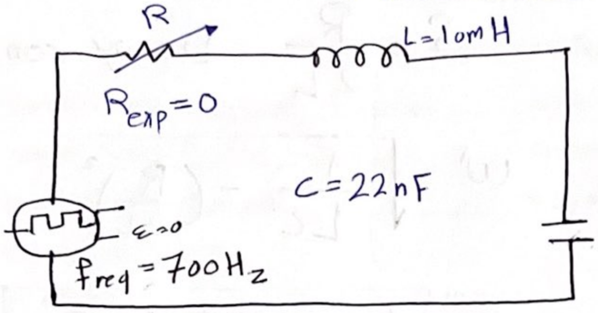
time constant t

$$\boxed{t_{thec} = \frac{L}{R}}$$

Experiment 7

Damped Oscillations

RLC-circet DC-pr--



There cases:

1. $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC} \Rightarrow \sqrt{-} \longrightarrow$ underdamping

2. $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC} \Rightarrow \sqrt{0} \longrightarrow$ critical damping

3. $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC} \Longrightarrow \sqrt{+} \longrightarrow$ over damping

---

$$\varepsilon = V_R + V_L + V_C$$

$$\varepsilon = IR + L\frac{dI}{dt} + \frac{Q}{C}$$

$$\varepsilon = R\frac{dQ}{dt} + L\frac{d^2Q}{dt^2} + \frac{Q}{C}$$

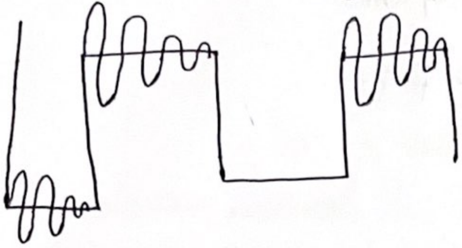
2^{nd} onder Linear diff eqution

$$Q(t) = A_1 e^{\lambda_+ t} + A_2 e^{\lambda_- t}$$

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

$\boxed{A_1 \, . \, A_2 \text{ constant}}$

$\boxed{1}$ under damping

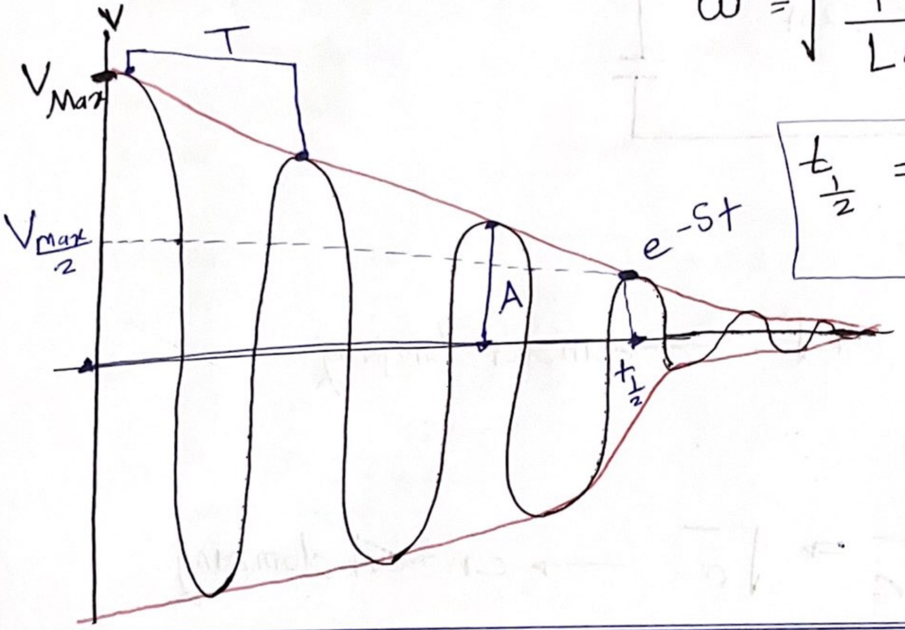


$$Q(t) = Q_0 e^{-St} \cos(\omega' t\ \emptyset)$$

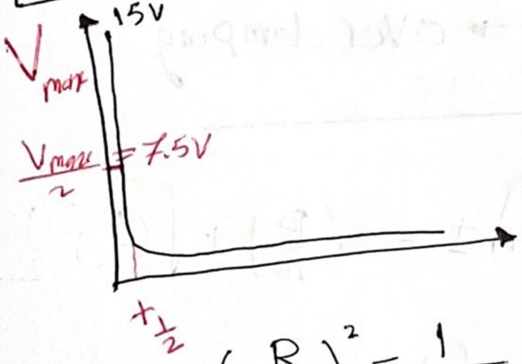
$$S = \frac{R}{2L} \quad \text{Decay constant}$$

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

$$\boxed{t_{\frac{1}{2}} = \frac{2L \ln 2}{R}}$$



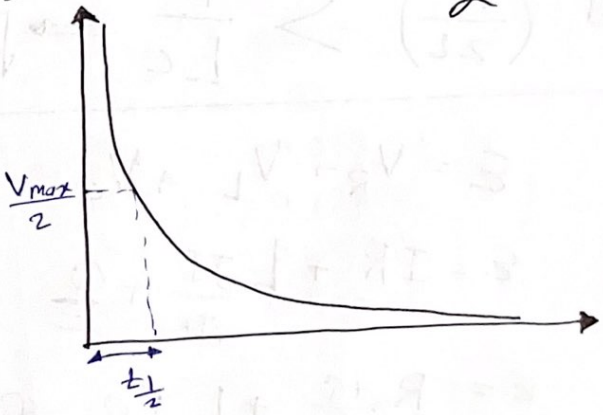
$\boxed{2}$ critical damping



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

$$S = \frac{\ln 2}{t_{\frac{1}{2}}}$$

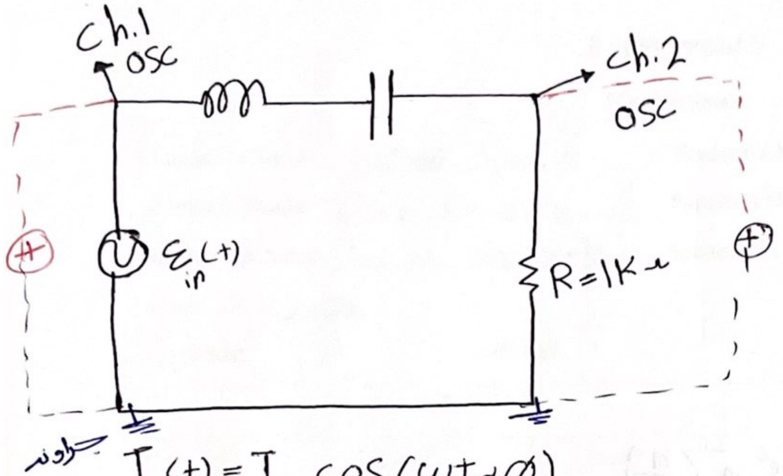
$\boxed{3}$ over damping



$$\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$$

$$S = \frac{\ln 2}{t_{\frac{1}{2}}}$$

Exp # 8 | Impedance and Reactance



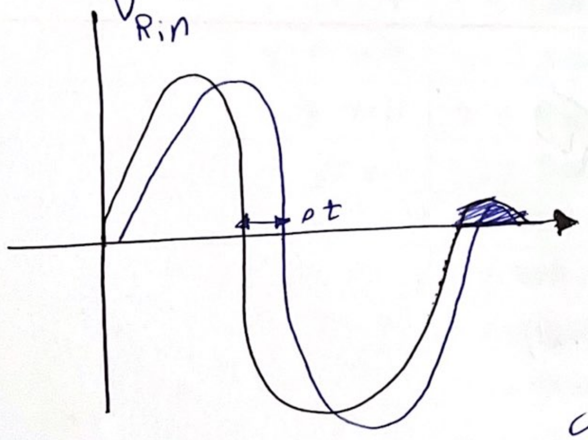
$$I(t) = I_0 \cos(\omega t + \varnothing)$$

$$I_0 = \frac{\mathcal{E}_0}{\sqrt{R + \left(\omega L + \frac{1}{\omega c}\right)^2}} \rightarrow \text{exp } 9$$

$$\boxed{\omega = 2\pi f}$$

$$\varnothing = \tan^{-1}\left(\frac{-\omega L + \frac{1}{\omega c}}{R}\right) \rightarrow \text{exp } 8$$

phase shift angle



internal mode

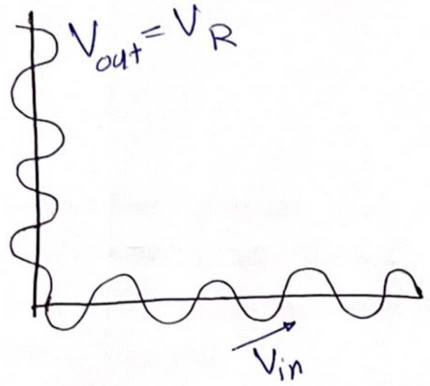
اي داخلة ← اصفر
اي طالعة ← ازرق

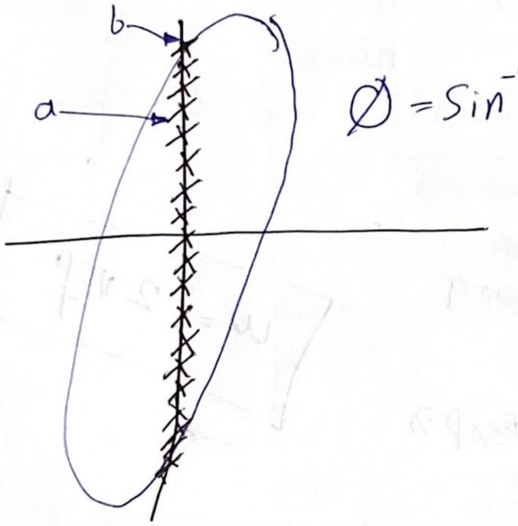
Δt ← المسافة الافقية بين 2P او تقطعهم محور السينات بجيب cursor

2P ← يعني قمتين

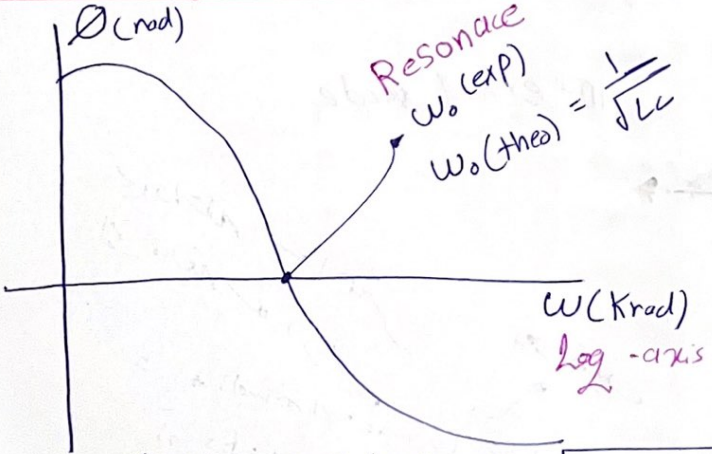
$$\varnothing\,(\text{phaseshift}) = \omega \Delta t$$
$$= 2\pi f \Delta t$$

extend mode





$\varnothing = \sin^{-1}\left(\frac{a}{b}\right)$

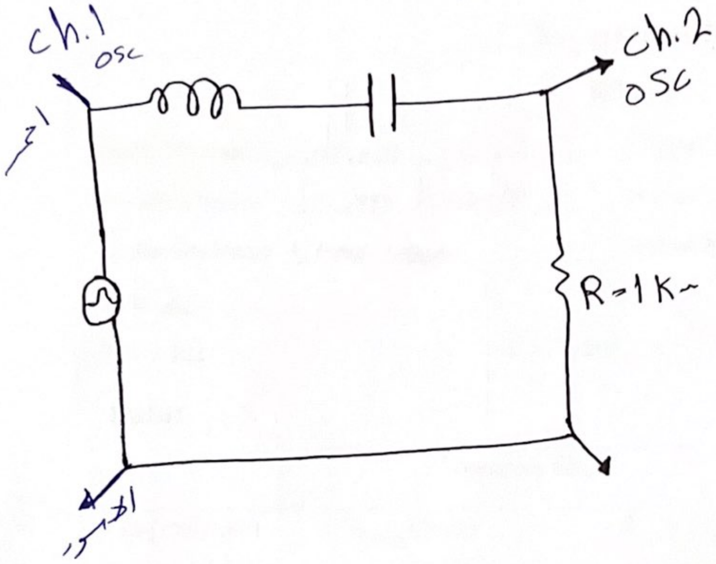


$I(t) \propto \cos(\omega t + \varnothing)$ $\boxed{V_R = IR}$

$Q(t) = \int I(t)\, dt \propto \sin(\omega t + \varnothing)$ $\boxed{V_c = \frac{R}{c}}$

$\frac{dI}{dt} \propto -\sin(\omega t + \varnothing)$ $\boxed{V_L = L\frac{dI}{dt}}$

$\boxed{\text{Exp \# 9}}$ Resonace



$$I(t) = I_0 \cos(\omega t + \phi)$$

$$I_0 = \frac{V_0}{\sqrt{R^2 + (\omega L - \frac{1}{\omega c})}}$$

of Resonace

$$(\omega_0 - \frac{1}{\omega c})^2 = 0$$

$$\omega_0 = \frac{1}{\sqrt{Lc}}$$

$$\boxed{I_0 = \frac{V_0}{R}}$$

$$Q = \frac{\omega L}{R}$$

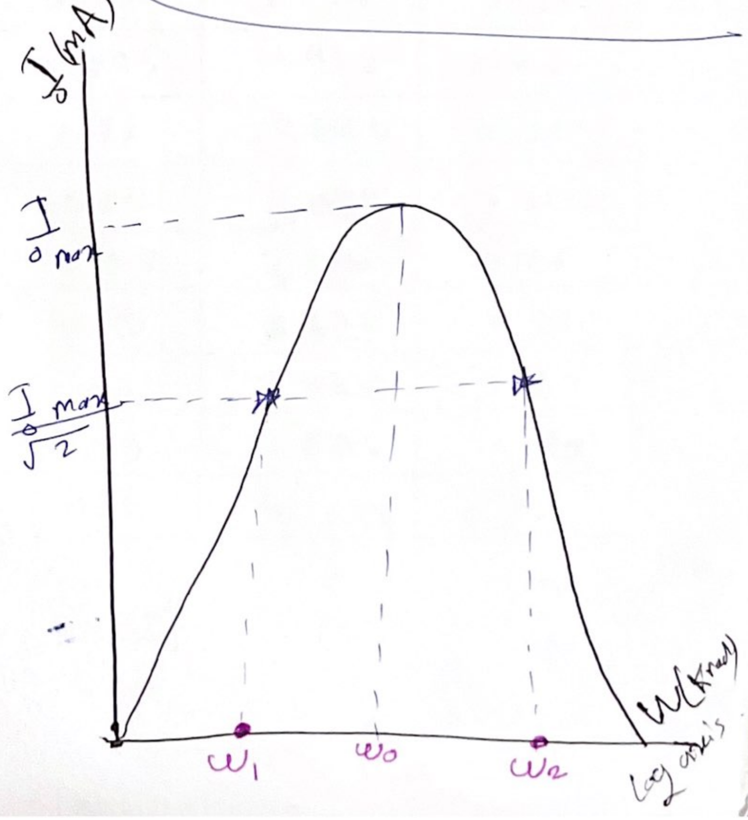
$$= \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{\omega_0}{|\Delta\omega|}$$

$\boxed{|\Delta\omega| : \text{band width}}$

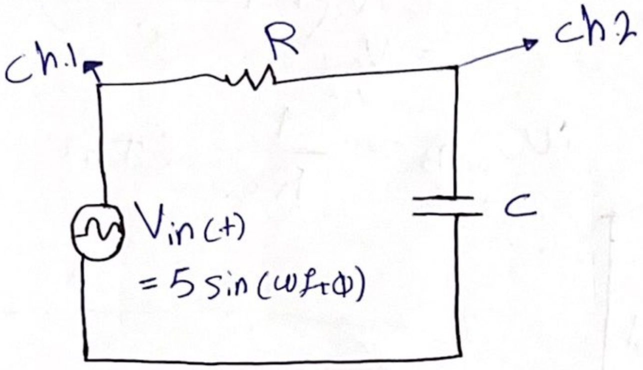
$$\omega_2 - \omega_1 = |\Delta\omega|$$

$$Q = \frac{\omega_0}{|\Delta\omega|}$$



Exp #10 | Filters

Low-pass filter



$$V(t) = V_c(t)$$

$$= \frac{V_{in}(t)}{1+j\omega RC}$$

$$\omega = 2\pi f$$

$j = \sqrt{-1}$ → complex number

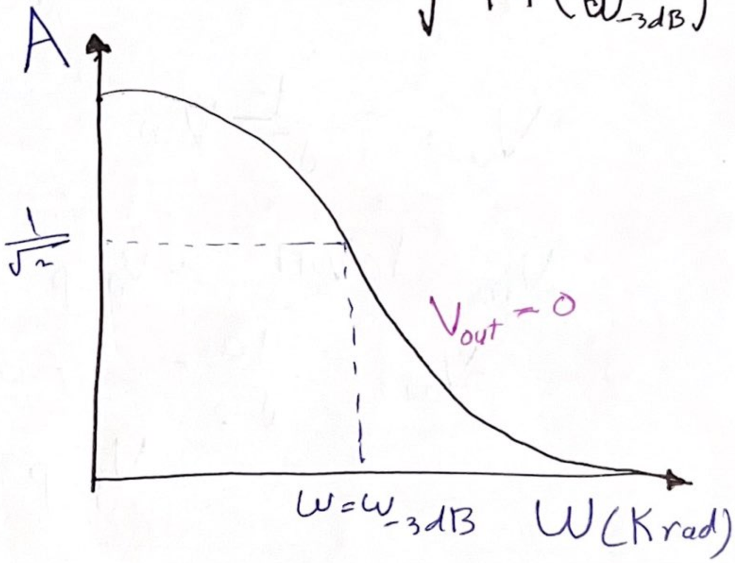
Amplintude

$$V_{co}(t) = \frac{V_{ino}}{\sqrt{1+\omega^2R^2C^2}}$$

$$\frac{1}{RC} = \omega_{-3dB}$$

A: Attenuation factor

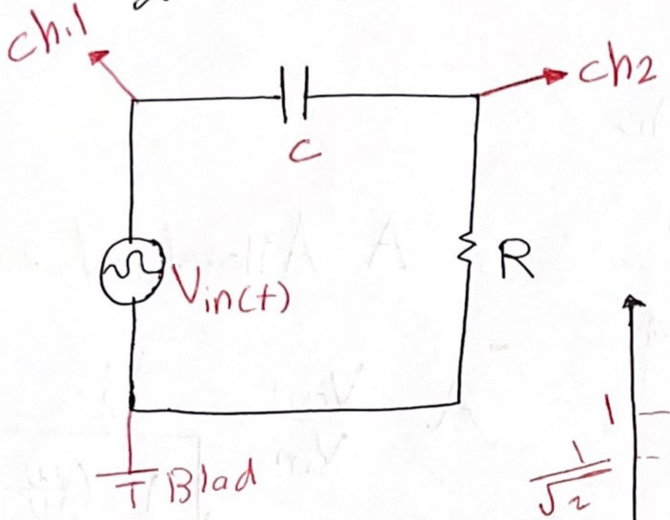
$$A = \frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_{-3dB}}\right)^2}}$$



$\omega \ll \omega_{-3dB}$ $\boxed{V_{out} = V_{in}}$

Mariam Ahmad Qadah

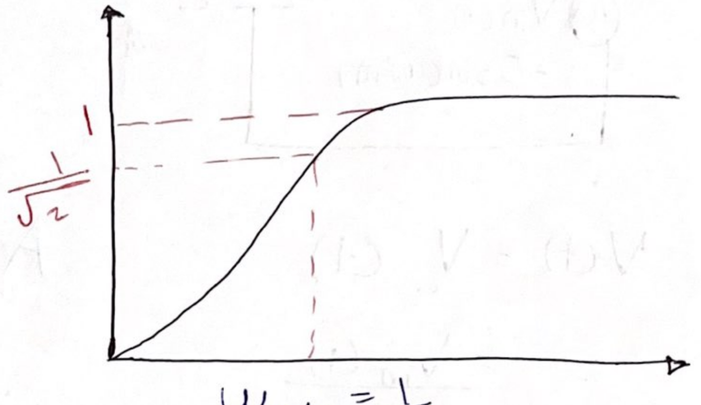
High-pass filters



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

$$= \frac{V_{out}}{V_{in}}$$

$$\omega_{-3dB} = \frac{1}{RC} \text{ (Th)}$$



$$\omega_{-3dB} = \frac{1}{Rc}$$

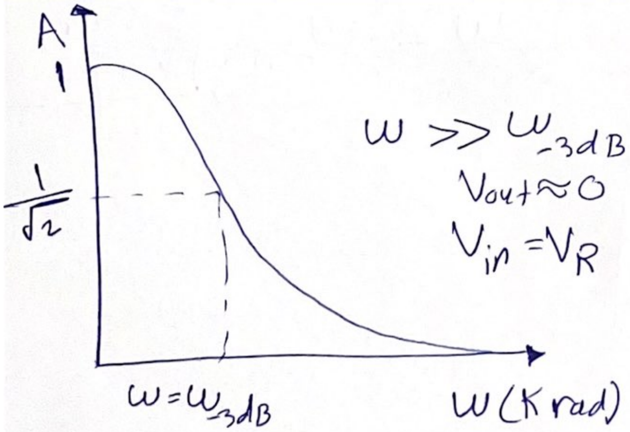
$$V_{out} = \frac{1}{\sqrt{2}} V_{in}$$

$V_{in} = 10 \text{ Volt} \rightarrow V_{p-p} = 20$

$$V_{out} = \frac{10}{\sqrt{2}} = 7.07 \text{ Vot}$$

$V_{p-p} = 14$

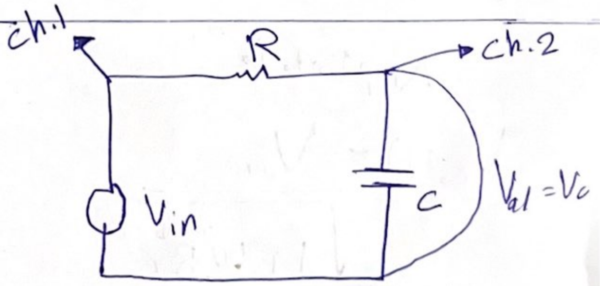
$$\boxed{f_{-3dB} = \omega_{-3dB} = 2\pi f_{-3dB}}$$



$\omega >> \omega_{-3dB}$

$V_{out} \approx 0$

$V_{in} = V_R$



$$V_{out} = V_c = \frac{Q}{C}$$

$$I(t) = \frac{dQ}{dt}$$

$$Q(t) = \int I(t)\, dt$$

$$V_{out} = V_c = \frac{Q}{c}$$

$$= \frac{1}{c}\int I(t)\, dt \times \frac{R}{R}$$

$$\frac{1}{Rc}\int \frac{RI(t)dt}{VR}$$