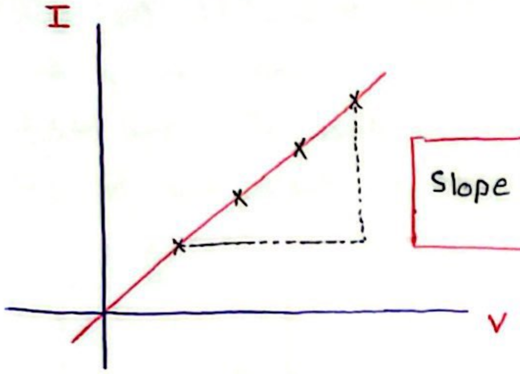
Francis Miadi.

1 linear & non linear elements

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

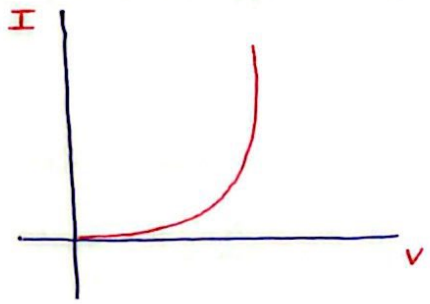
i) for linear elements



$$\text{Slope} = \frac{\Delta I}{\Delta V} = \frac{1}{R}$$

example: Carbon Resistor
Light bulb

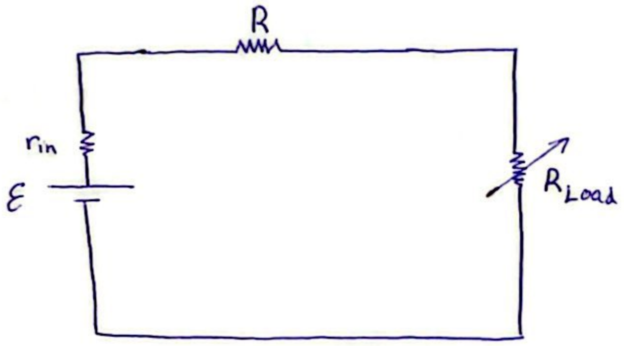
ii) for non linear elements

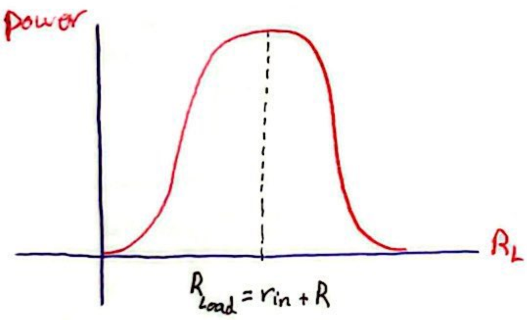


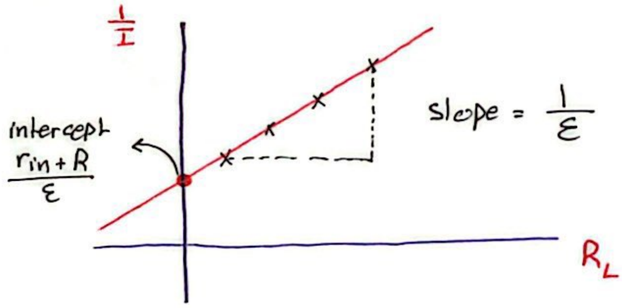
example: Diode

2 Internal Resistance & Impedance Matching

power $= I^2 R_L$

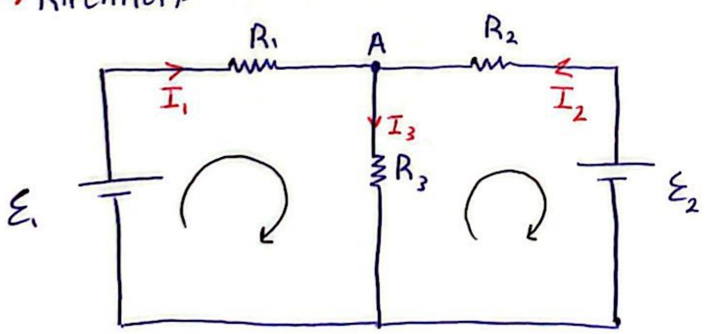






3

i) Kirchhoff



by $\sum_{\Omega} V = 0$ → we get 2 & 3

& by $\sum I_{in} = \sum I_{out}$ → we get 1

① $I_1 + I_2 = I_3$

② $\mathcal{E}_1 - I_1 R_1 - I_3 R_3 = 0$

③ $\mathcal{E}_2 - I_2 R_2 - I_3 R_3 = 0$

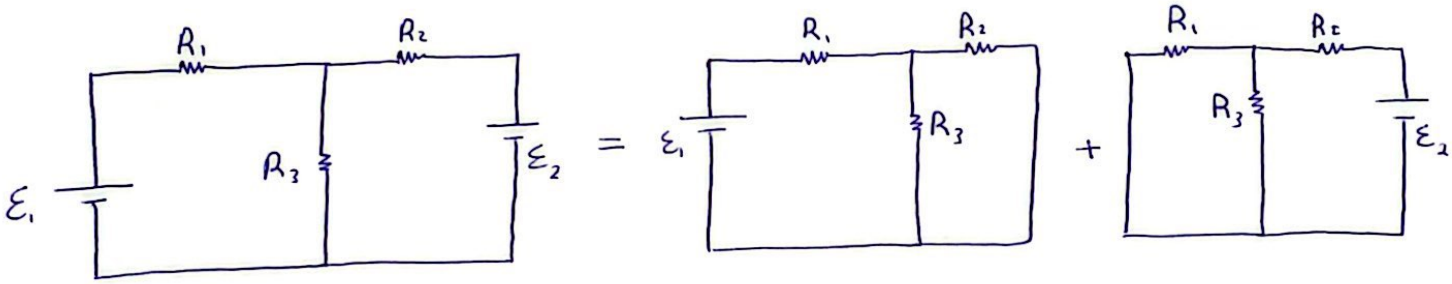
ii) Superposition (spp)

* Steps:-

1) Turn off all sources except one source, find the output (voltage or current) due to that source

2) Repeat step 1 for each of the other sources

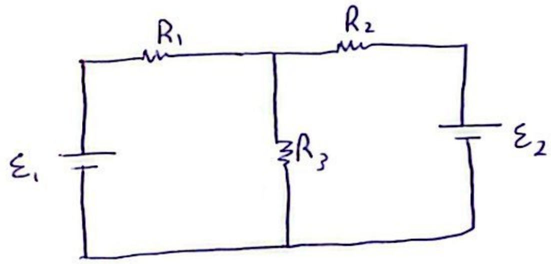
3) Find the total output by adding algebraically all the outputs due to each source.



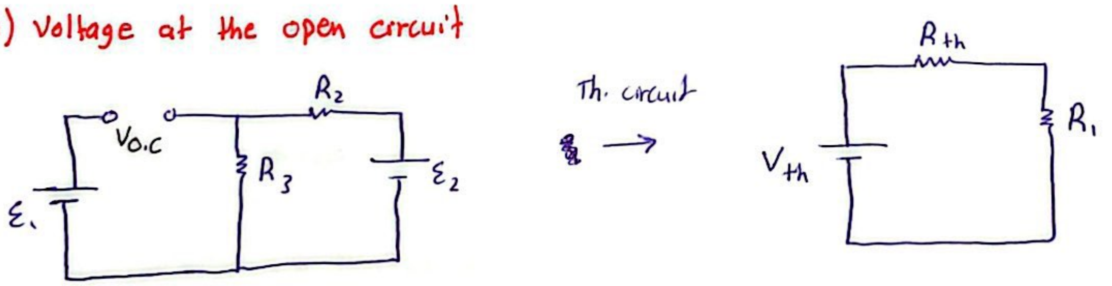
4 Thevenin Equivalent Circuit

Assume we have the following circuit →

* we can find the Thevenin equivalent circuit by two ways:-



i) Voltage at the open circuit

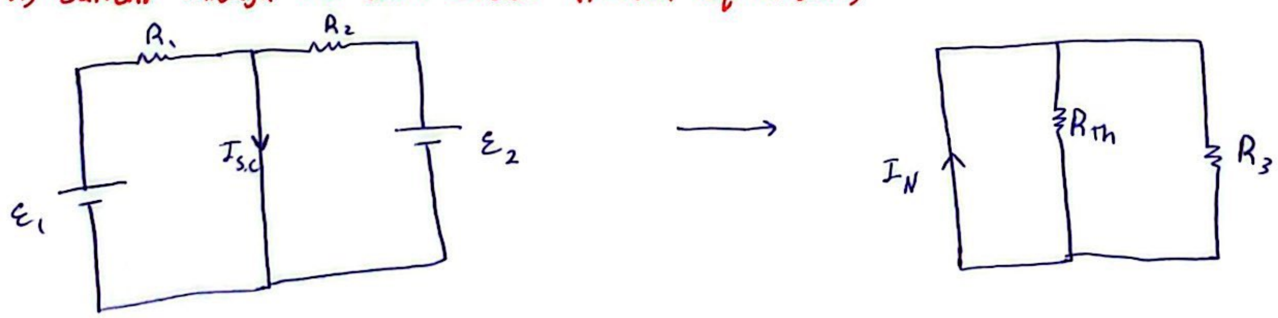


$V_{th} = V_{o.c}$ & $R_{th} = R_{eq}$

by Kirchhoff in exp 3 ($V_{o.c}$)

$R_{eq} = \frac{R_2 R_3}{R_2 + R_3}$

ii) current through the short circuit (Norton eq. circuit)

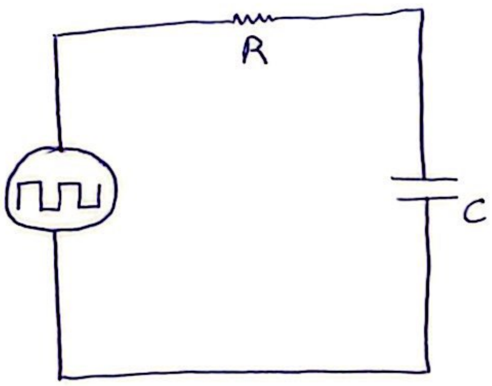


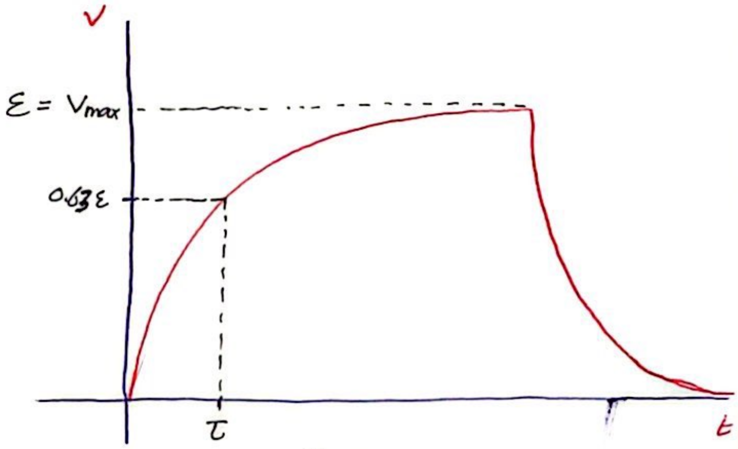
$$I_N = I_{s.c} = \frac{\mathcal{E}_1}{R_1} + \frac{\mathcal{E}_2}{R_2}$$

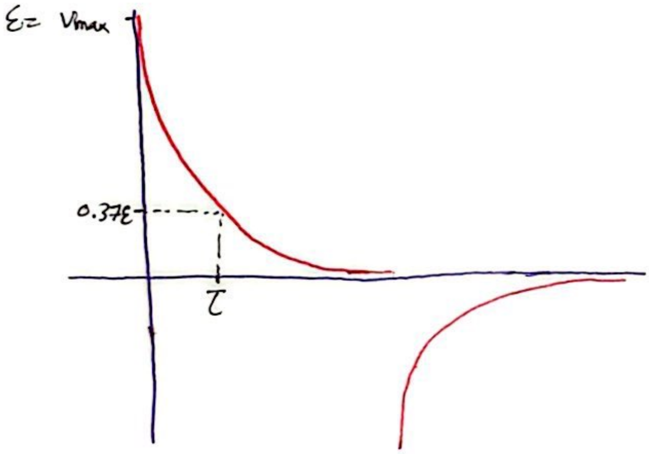
$$R_{th} = R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

5 Capacitors & Inductors

i) RC Circuits → Resistor & capacitor



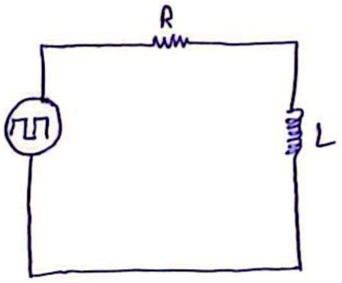


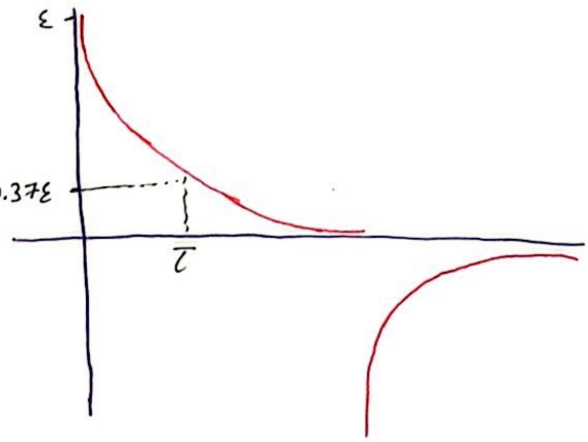


$\tau_{theo} = RC$

$\tau_{exp} = \frac{\tau_{charging} + \tau_{discharging}}{2}$

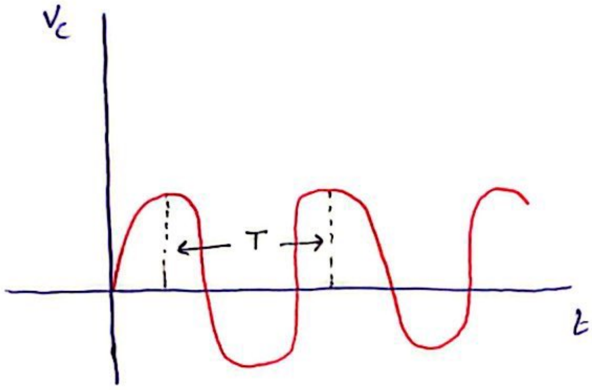
ii) RL circuits → Resistor & Inductor





$\tau_{theo} = \frac{L}{R}$

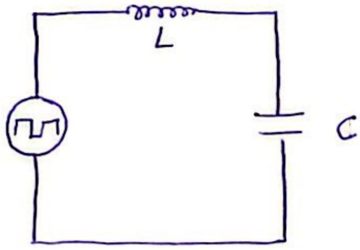
iii) LC circuits ⟶ Inductor & capacitor



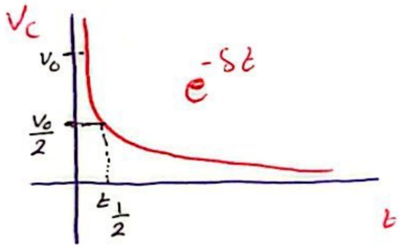
$\omega = 2\pi f$

$f_{exp} = \frac{1}{T}$

$f_{o\,theo} = \frac{1}{2\pi\sqrt{LC}}$

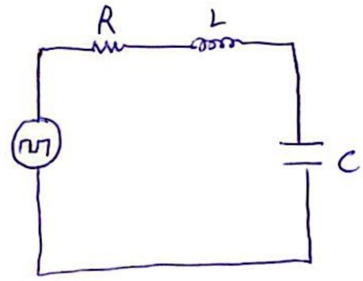


6 Damping



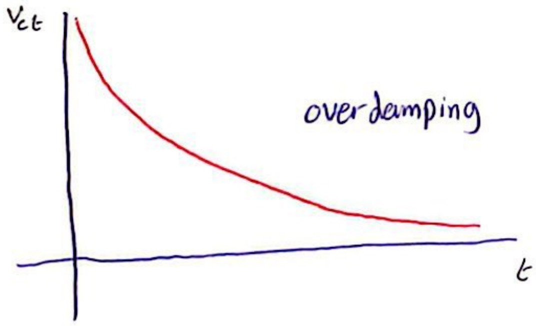
$V_c = V_0 e^{-\delta t}$

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

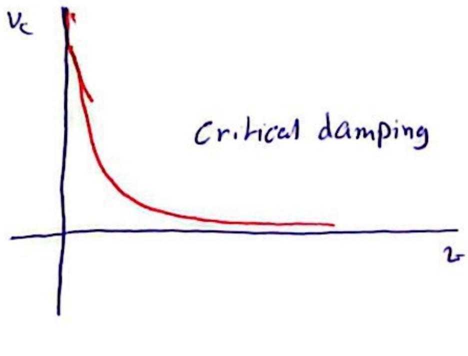


case 1)

if $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$ then it is called over-damping

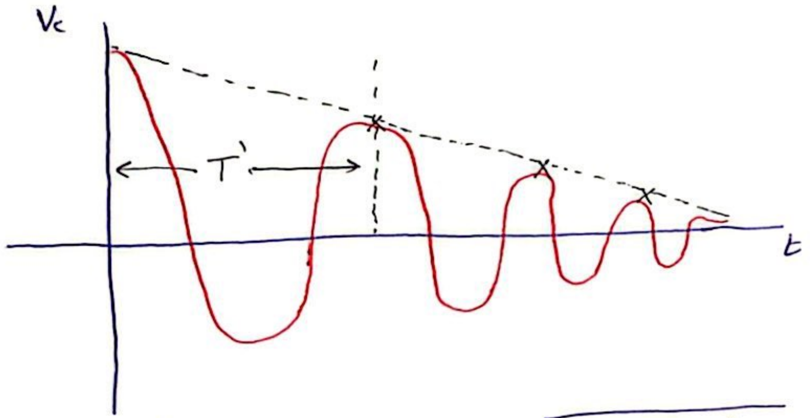


case 2) if $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$ then it is a critical damping



Case 3)

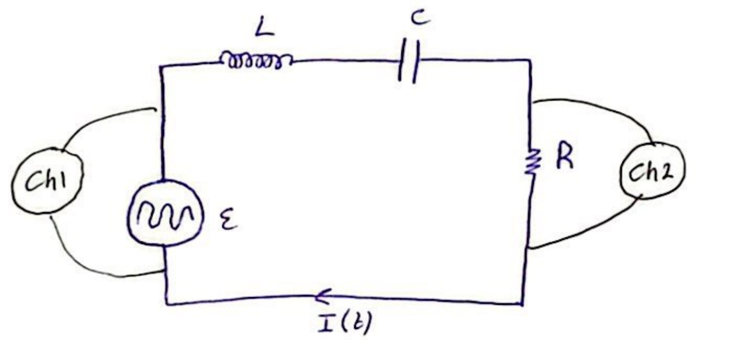
if $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$ then it is Underdamping



$f'_{exp} = \frac{1}{T'}$ $\qquad f'_{theo} = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$

7 Impedance & Reactance

Impedance	Reactance
$Z_R = R$	$\lvert Z_R \rvert = R$
$Z_C = \frac{-j}{wC}$	$\lvert Z_C \rvert = \frac{1}{wC}$
$Z_L = jwL$	$\lvert Z_L \rvert = wL$
$j = \sqrt{-1}$	

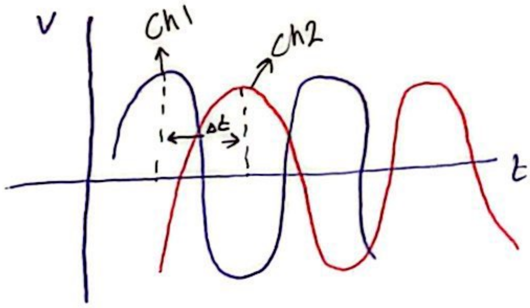


$\mathcal{E}(t) = \mathcal{E}_o \cos wt$

$I(t) = I_o \cos(wt + \Phi)$

$w = 2\pi f$

$$I_o = \frac{\mathcal{E}_o}{\sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}}$$



Ch1 leads ch2

because it started before ch2

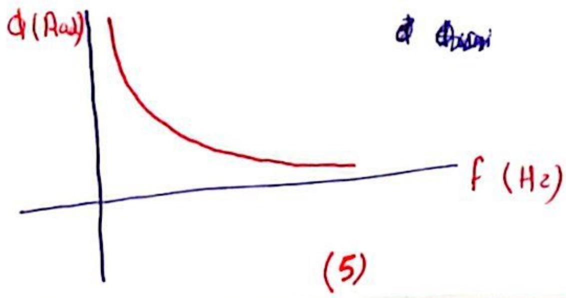
and we also can say that

ch2 lags ch1

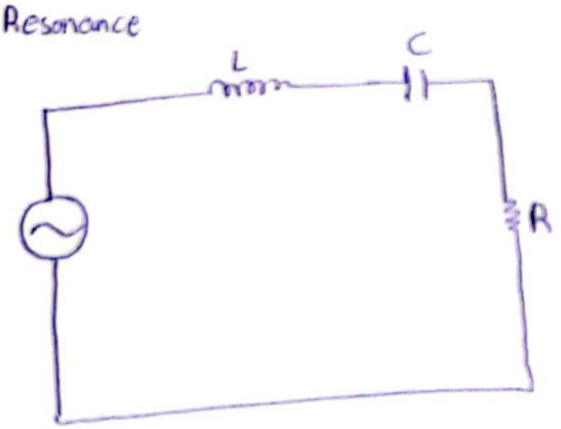
Phase shift Φ → Unit is Rad

$\Phi_{exp} = w\Delta t$

$$\Phi_{theo} = \tan^{-1}\left(\frac{-wL + \frac{1}{wC}}{R}\right)$$



8 Resonance

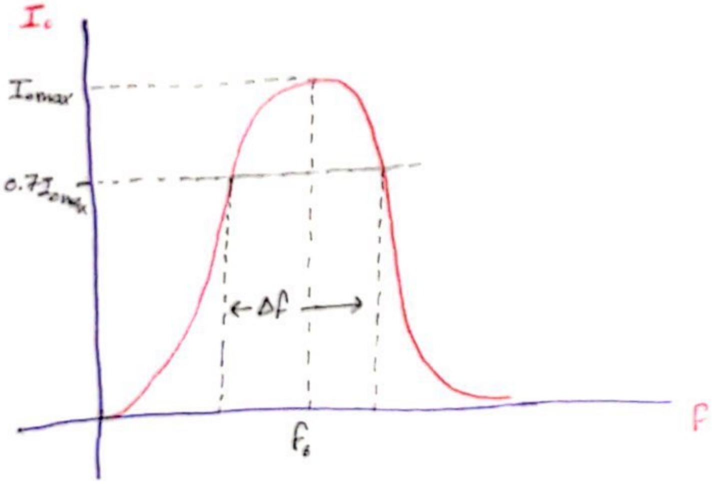


$$I_o = \frac{V_o}{\sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}}$$

$I_{o\,max}$ occurs at $w_oL = \frac{1}{w_oC}$

OR $w_o = \frac{1}{\sqrt{LC}}$

$$I_{o\,max} = \frac{V_o}{R}$$



Δw = bandwidth

Q = Quality factor

$$Q_{exp} = \frac{f_o}{\Delta f}$$

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