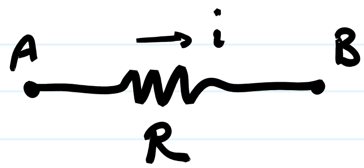
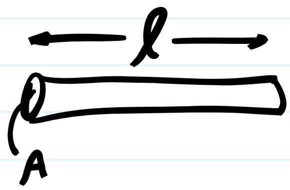
Ideal resistor



$i = \frac{1}{R}(v_A - v_B)$

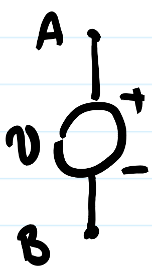


for a wire : $R = \rho \frac{l}{A}$

l → length

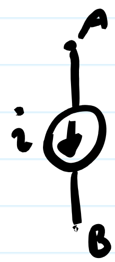
A → cross-sec area

ρ → Resistivity of material



voltage source:

$v = v_A - v_B$

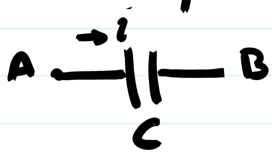


Current source

$i_{AB} = i$ (given)

Power dissipation in resistor: $P = Ri^2 = \frac{v^2}{R}$

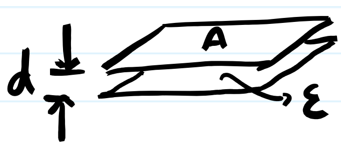
Ideal capacitor.



$q = c(v_A - v_B)$ or $q = cv$

c → capacitance

q → charge



$C = \frac{\varepsilon A}{d}$

A → Area of flat plates

d → distance of the plates.

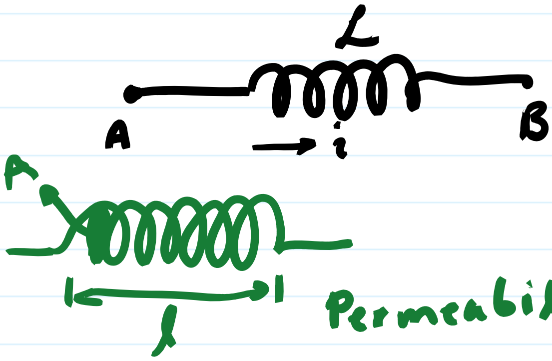
ε → dielectric const.

$i = \frac{dq}{dt} = c\frac{dv}{dt} \Rightarrow dv = \frac{1}{c} i dt$

or $v = v_0 + \frac{1}{c}\int_0^t i\, dt$

Stored energy in capacitor: $w = \frac{1}{2} c v^2$

* Inductor:



$$v_A - v_B = L\frac{di}{dt} \quad [H]$$

# of turns

$$L = \frac{\mu N^2 A}{l}$$

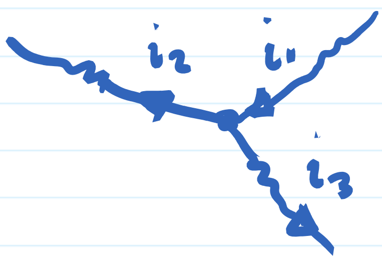
Permeability — μ

Cross-sectional area — A

length — l

* Kirchhoff's Current Law (KCL):

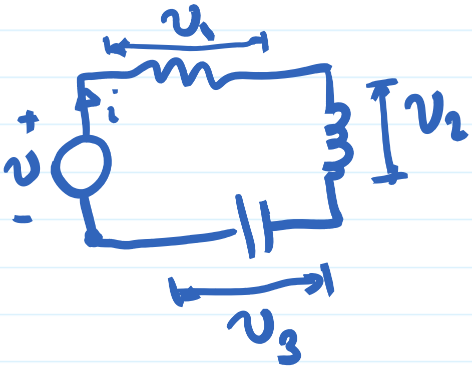
Sum of the currents entering a node is equal to sum of currents leaving that node



$$i_1 = i_2 + i_3$$

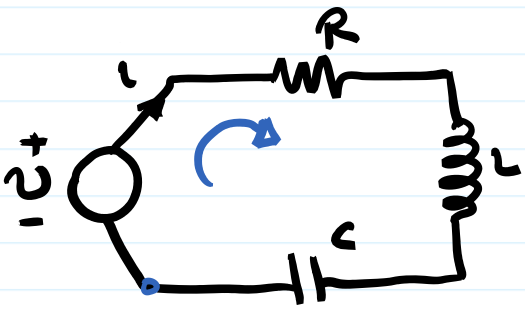
* Kirchhoff's Voltage Law (KVL).

Sum of all the voltage changes around a complete loop is zero



$$v - v_1 - v_2 - v_3 = 0$$

* RLC circuit:



KVL: $v - iR - L\frac{di}{dt} - \frac{1}{C}\int i\,dt = 0$

$$L\frac{di}{dt} + Ri + \frac{1}{C}\underbrace{\int i\,dt}_{q} = v$$

if $q = \int i\,dt$ $\quad i = \dot{q}$ $\quad \frac{di}{dt} = \ddot{q}$

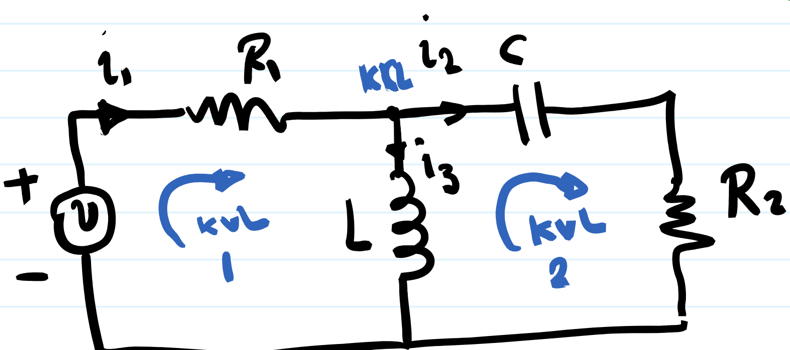
$$\Rightarrow \boxed{L\ddot{q} + R\dot{q} + \frac{1}{C}q = v}$$

Standard second order oscillator

$$m\ddot{x} + c\dot{x} + kx = f$$

$m \to L$, $c \to R$, $k \to 1/C$

inertia element — damping — spring constant or energy storage element.



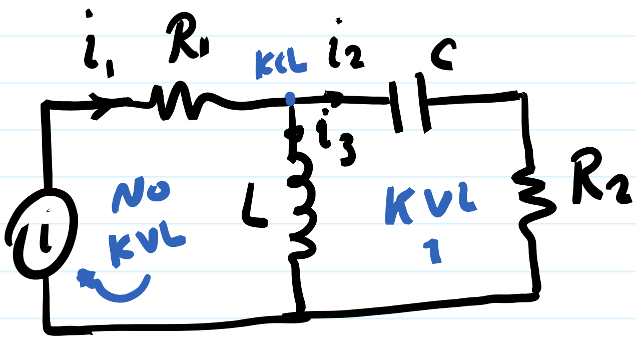
KVL 1: $v - i_1R_1 - L\frac{di_3}{dt} = 0$

KVL 2: $-\frac{1}{C}\int i_2\,dt - R_2 i_2 + L\frac{di_3}{dt} = 0$

KCL: $i_1 = i_2 + i_3$

Let's replace i_3 by $i_1 - i_2$

$$\begin{cases} L\dfrac{di_1}{dt} - L\dfrac{di_2}{dt} + R_1 i_1 = v \\ L\dfrac{di_2}{dt} - L\dfrac{di_1}{dt} + R_2 i_2 + \dfrac{1}{C}\int i_2\, dt = 0 \end{cases}$$



KCL: $i_1 = i_2 + i_3$

$i = i_2 + i_3$

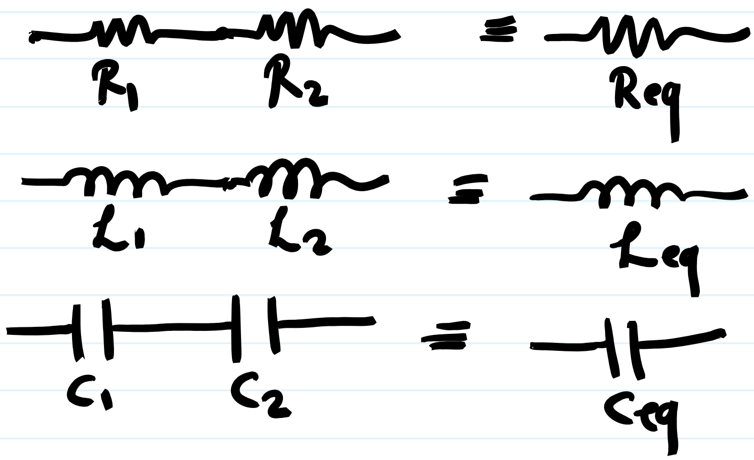
$i_3 = i - i_2$

$$-\frac{1}{C}\int i_2\, dt - i_2 R_2 + L\frac{d\overbrace{(i-i_2)}^{i_3}}{dt} = 0$$

or. $$L\frac{di_2}{dt} + R_2 i_2 + \frac{1}{C}\int i_2\, dt = \underbrace{L\frac{di}{dt}}_{\text{input}}$$

Series and parallel Resistors/Capacitors/Inductors:

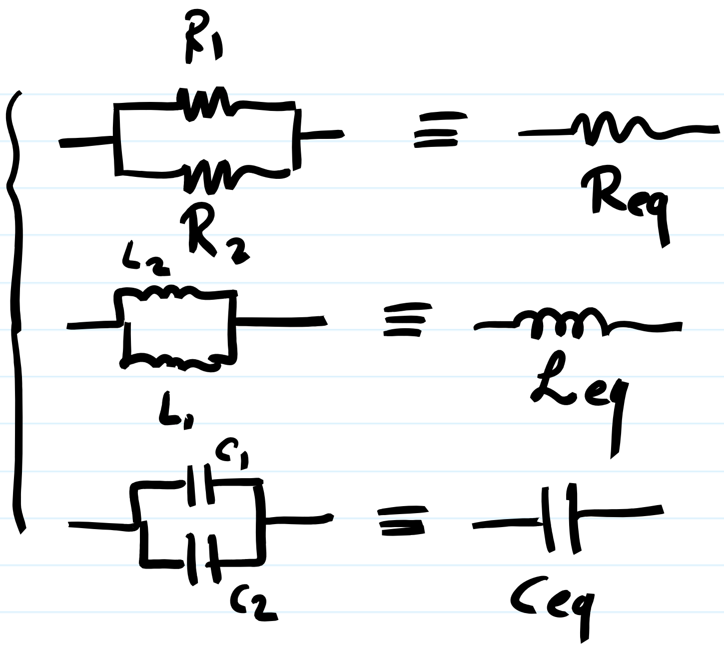
Series



$R_{eq} = R_1 + R_2$

$L_{eq} = L_1 + L_2$

$1/C_{eq} = 1/C_1 + 1/C_2$

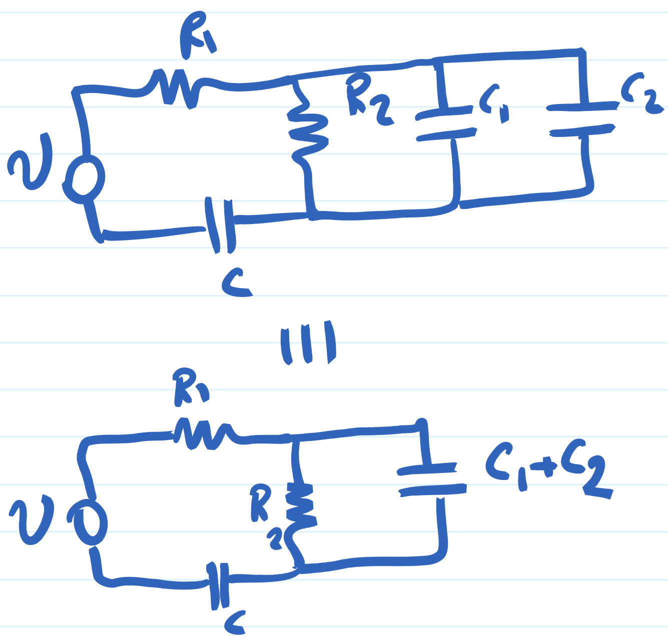


$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

$$C_{eq} = C_1 + C_2$$

exp.



Simplify first, then write the KVL & KCL equations