Class # 1

Basics

Ohm's Law : $V = I R$

current $\left[A = \frac{C}{s} \right]$

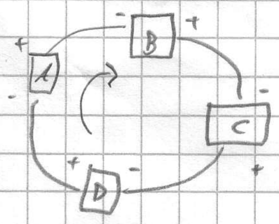
voltage $\left[V = \frac{J}{C} \right]$

resistance $\left[\Omega = \frac{V}{A} = \frac{J \cdot s}{C^2} \right]$

Kirchhoff's Laws :

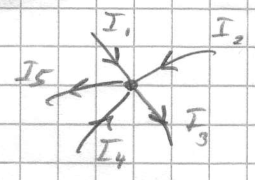
Sum of voltages around a loop is <u>zero</u>.

(conservation of energy)



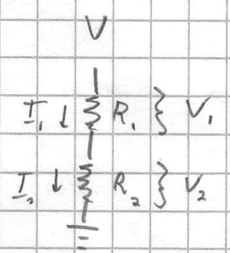
Sum of currents in and out of a node is <u>zero</u>.

(conservation of charge)



Applications:

series



$I_{total} = I_1 = I_2$

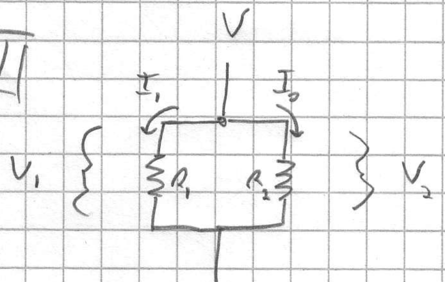
$V_{total} = V_1 + V_2$

$V_{total} = I_1 R_1 + I_2 R_2 = I_{total}(R_1 + R_2)$

$V_{total} = I_{total} \, R_{total}$

$R_{total} \rightarrow (R_1 + R_2)$

parallel



$I_{total} = I_1 + I_2$

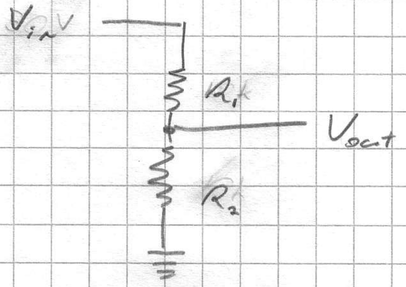
$V_{total} = V_1 = V_2$

$I_{total} = \frac{V_1}{R_1} + \frac{V_2}{R_2} = V_{total} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$

$V_{total} = I_{total} \, R_{total}$

$R_{total} \rightarrow \left(\frac{R_1 R_2}{R_1 + R_2} \right)$

Voltage Divider

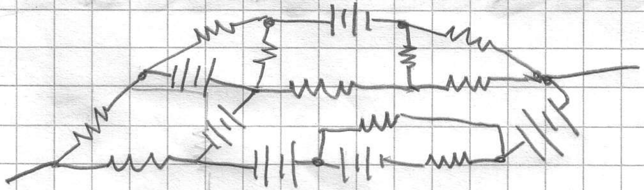


Method 1 : $I = \dfrac{V_{in}}{R_1 + R_2}$

$V_{out} = I \cdot R_2$

Method 2 : $V_{out} = V_{in} \left(\dfrac{R_2}{R_1 + R_2} \right)$

Thevenin's Equivalent Circuit



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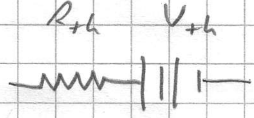
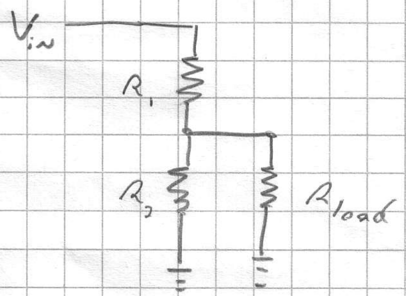


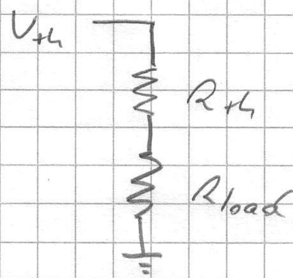
$V_{th} = V$ (open circuit)

$R_{th} = \dfrac{V \text{ (open circuit)}}{I \text{ (short circuit)}}$

Example :

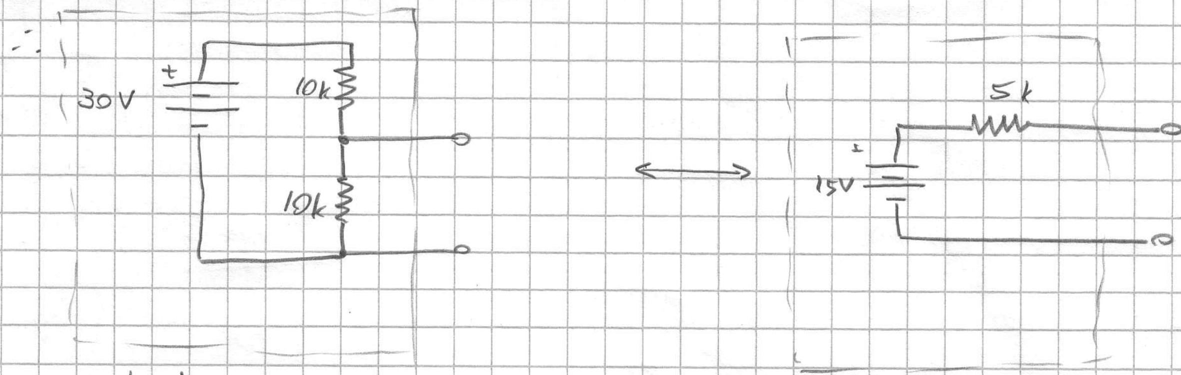


$\longrightarrow$



$$V_{th} = V_{in} \frac{R_2}{R_1 + R_2}$$

$$R_{th} = \frac{V_{in} \left(\frac{R_2}{R_1 + R_2} \right)}{\left(\frac{V_{in}}{R_1} \right)} = \frac{R_1 R_2}{R_1 + R_2}$$



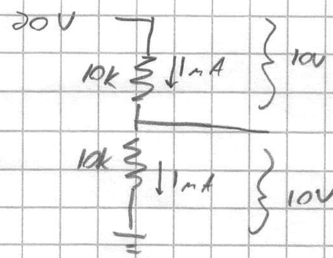
actual

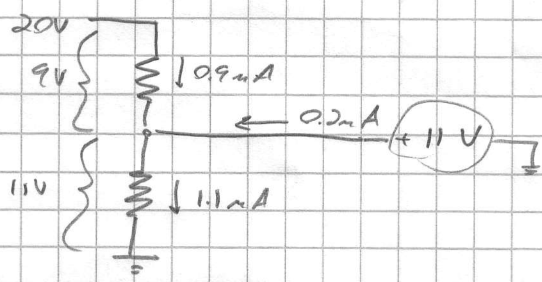
Thevenin

Short cut for calculating R_{th}:

> R_{thev} is the parallel resistance of the several resistances viewed from the output.

<u>Example</u>

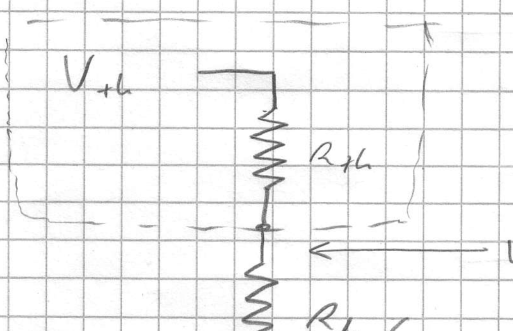




$$\frac{\Delta V}{\Delta A} = \frac{1\ V}{0.2\ mA} = 5\ k\Omega \longleftarrow R_{th}$$

To find impedance at a point, find ΔV & ΔA at that point.

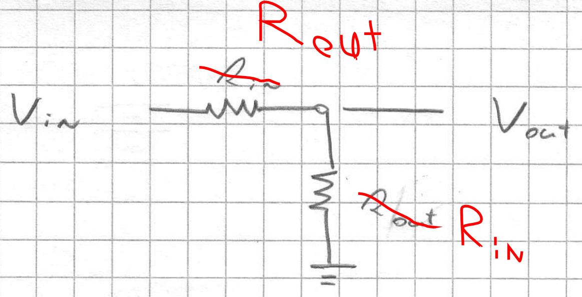
<u>Input & Output Impedance</u>



$$V_{out} = V_{th} \frac{R_{load}}{R_{th} + R_{load}}$$

$V_{out} \approx V_{th}$ for $R_{load} >> R_{th}$

$V_{out} \to 0$ for $R_{load} << R_{th}$



Always design such that

R_{out} ~~>>~~ << R_{in}

output impedance (from load)

input impedance (from instrument)