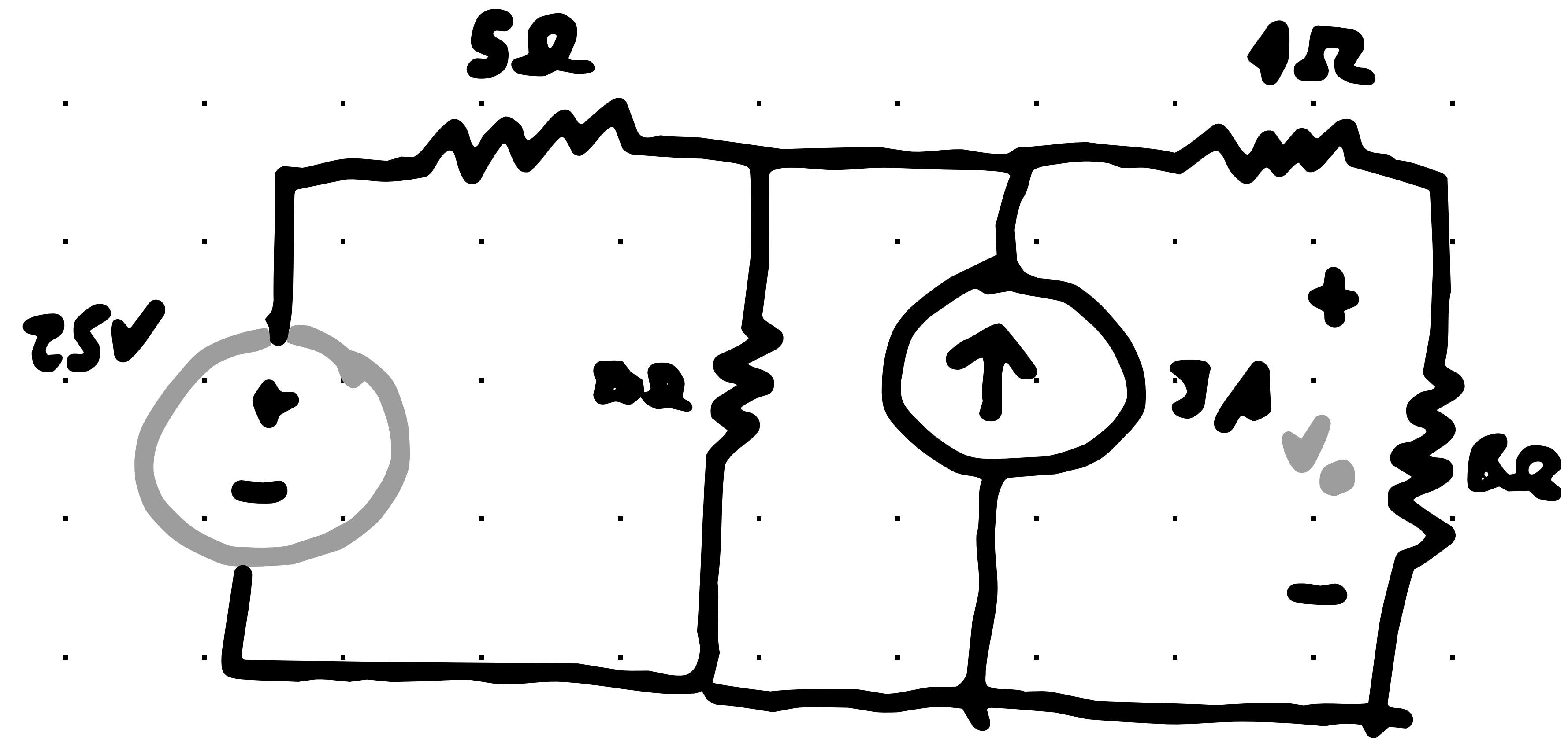
5 Superposition Theorem

A linear circuit excited by multiple sources will have a response which is the sum of the individual responses.

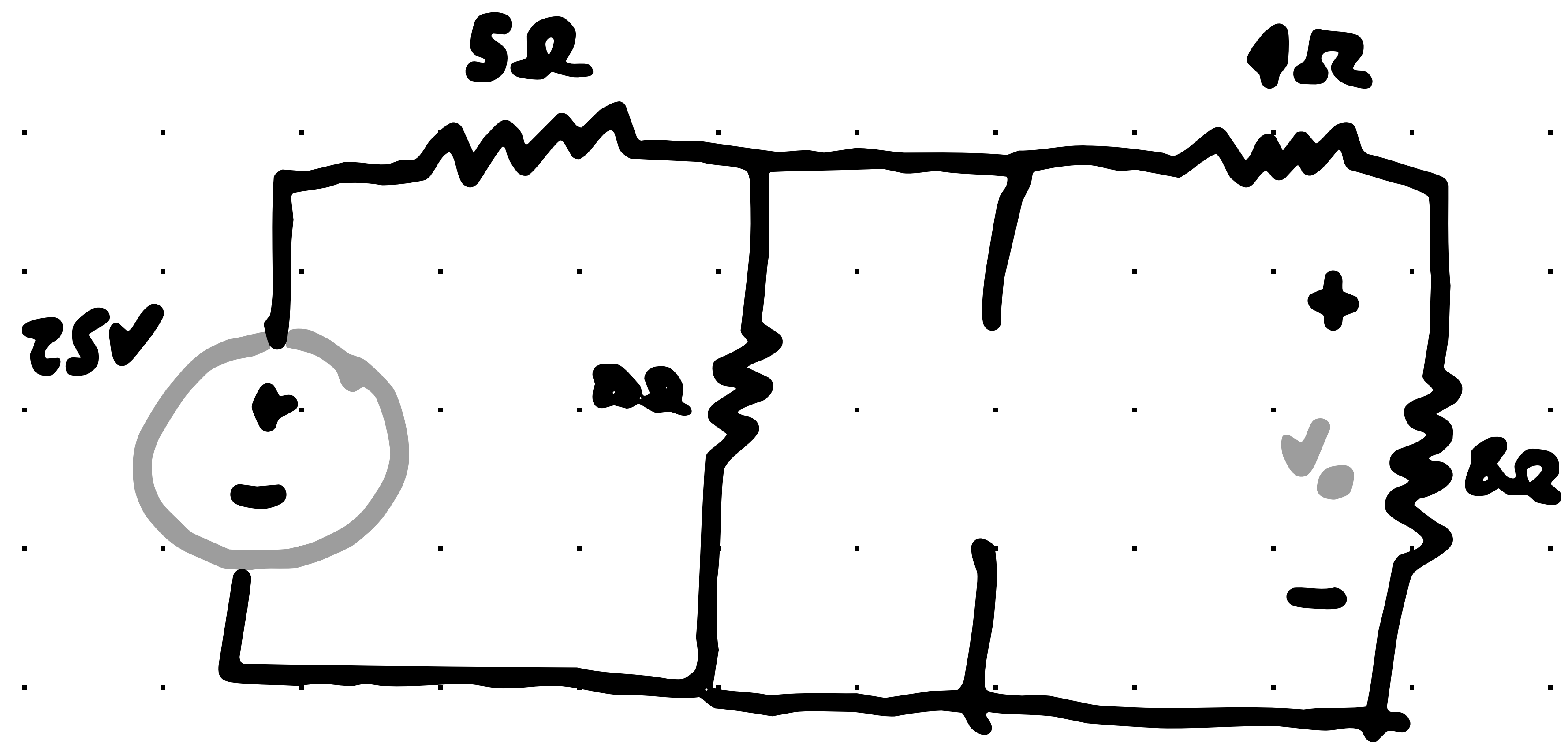
Ex: Find V_o using the Superposition theorem



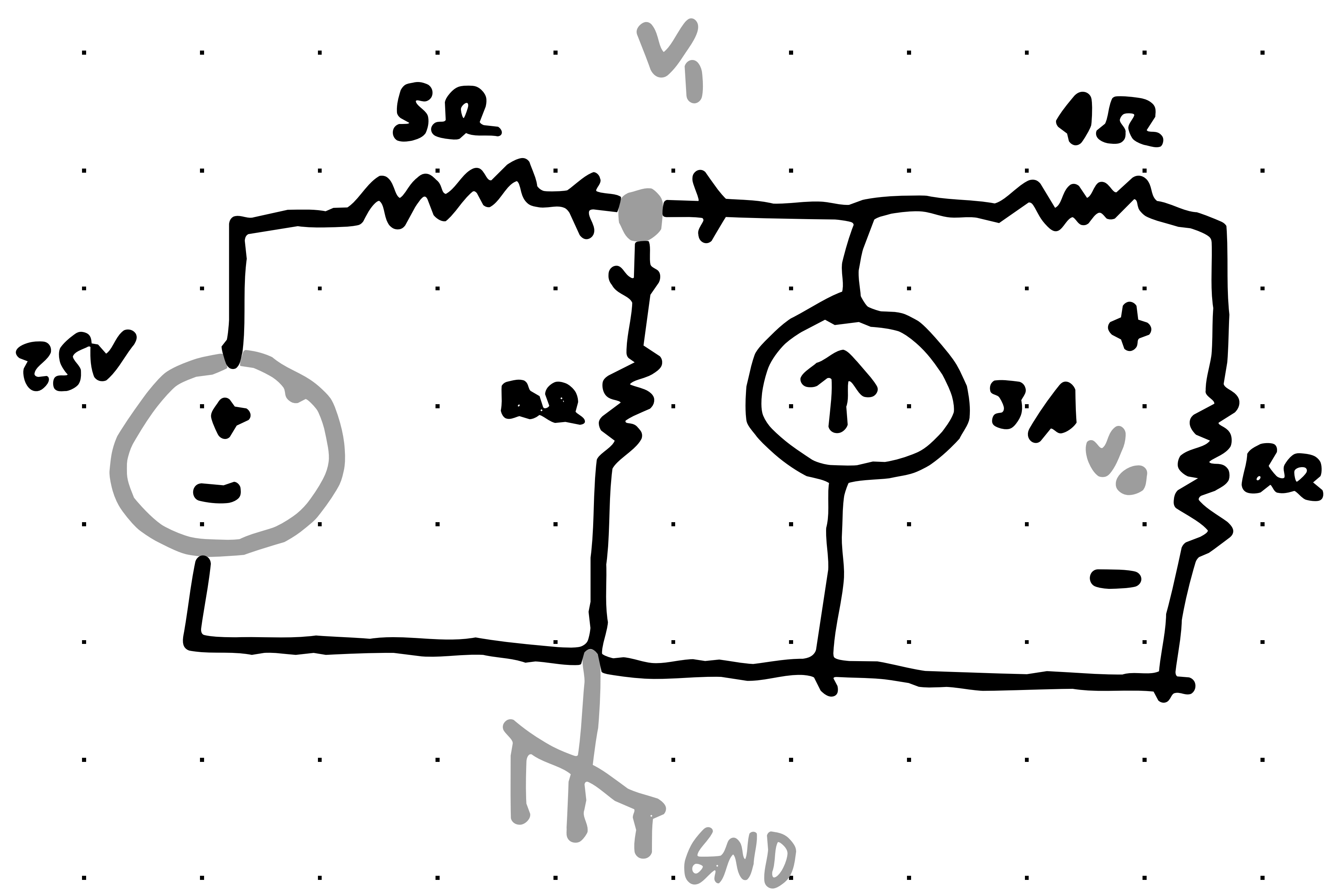
- Removing a Voltage Source requires a Short Circuit to be Swapped in.
- Removing a Current Source requires an open Circuit to be Swapped in.

Solution

Apply 25V, and remove 3A



Let's begin by Solving with Nodal Analysis



$\sum I = 0$

@ Node 1

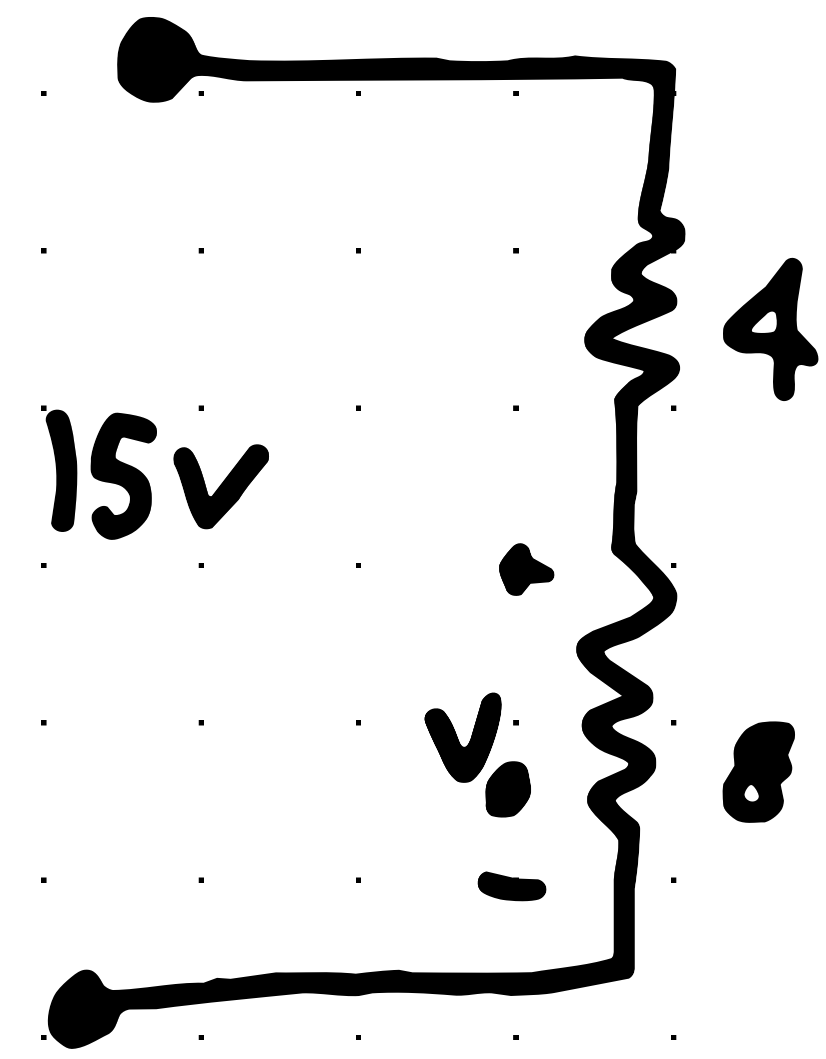
$$\frac{V_1 - 25}{5} + \frac{V_1}{20} + \frac{V_1}{25} = 0$$

* Factor, and move over $\frac{25}{5}$

$$V_1\left[\frac{1}{5} + \frac{1}{20} + \frac{1}{12}\right] = \frac{25}{5} = 5$$

$$V_1 = 5(3) = 15V$$

Now, Lets Solve it using Voltage divider



$$V_o' = V_1 \left(\frac{8}{4+8}\right) = 10V$$

Note For High-Schoolers :)

You can also solve this problem using a concept known as "**Ohm's Law**"

$$V = IR$$

(Voltage) (current) (Resistance)

This is a **VERY** Fundamental idea that if you ever work electricity, you will 100% deal with. Everything we did today builds on this. It might be worth re-visiting in the future!

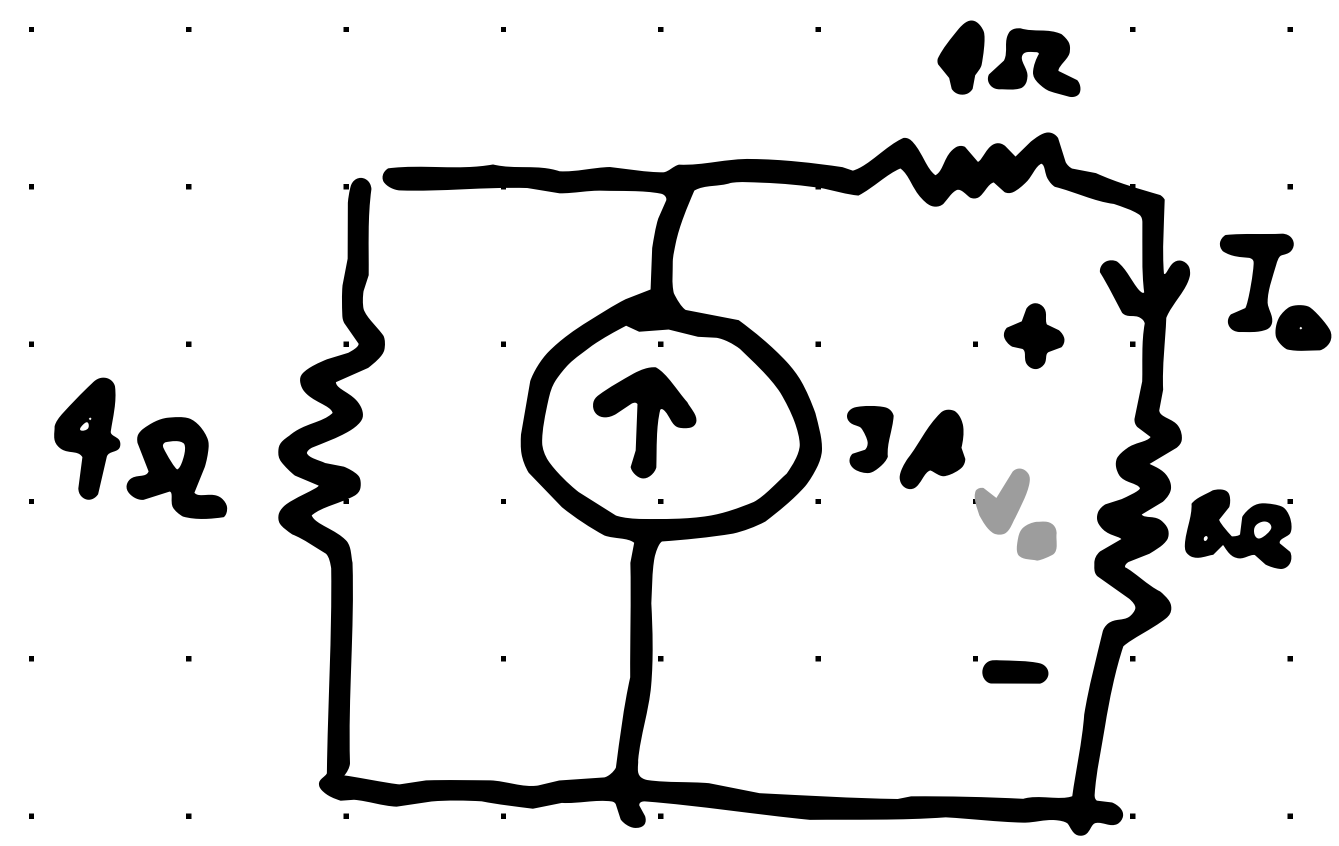
(You will see in PHYC 12)

Now, lets remove the voltage source instead!

Ohm's Law!

$$5 // 20 = \frac{5(20)}{5+20} = 4\Omega$$

(Parallel)



Using current divider (Variance of Ohm's Law)

$$I_o = 3\left(\frac{4}{4+(4+8)}\right) = 0.75A$$

So,

$$V_o'' = 8(0.75) = 6V$$

$$V_o = V_o' + V_o'' + \underbrace{10}_{\text{Last Page}} + 6 = 16V$$

NOTE:

You cannot use these superposition created "Vo'" and "Vo''" to calculate power.

$$P' = \frac{V_o'^2}{R} = \frac{10^2}{8} = 12.5\,W$$

$$P'' = \frac{V_o''^2}{R} = \frac{6^2}{8} = 4.8\,W$$

$P = VI$ and $P = \frac{V^2}{R}$ are non linear!

$$P_{8\Omega} \neq P' + P''$$

ie..

$$\frac{V_o^2}{R} \neq \frac{(V_o')^2}{R} + \frac{(V_o'')^2}{R}$$

$$V_o^2 \neq V_o'^2 + V_o''^2$$

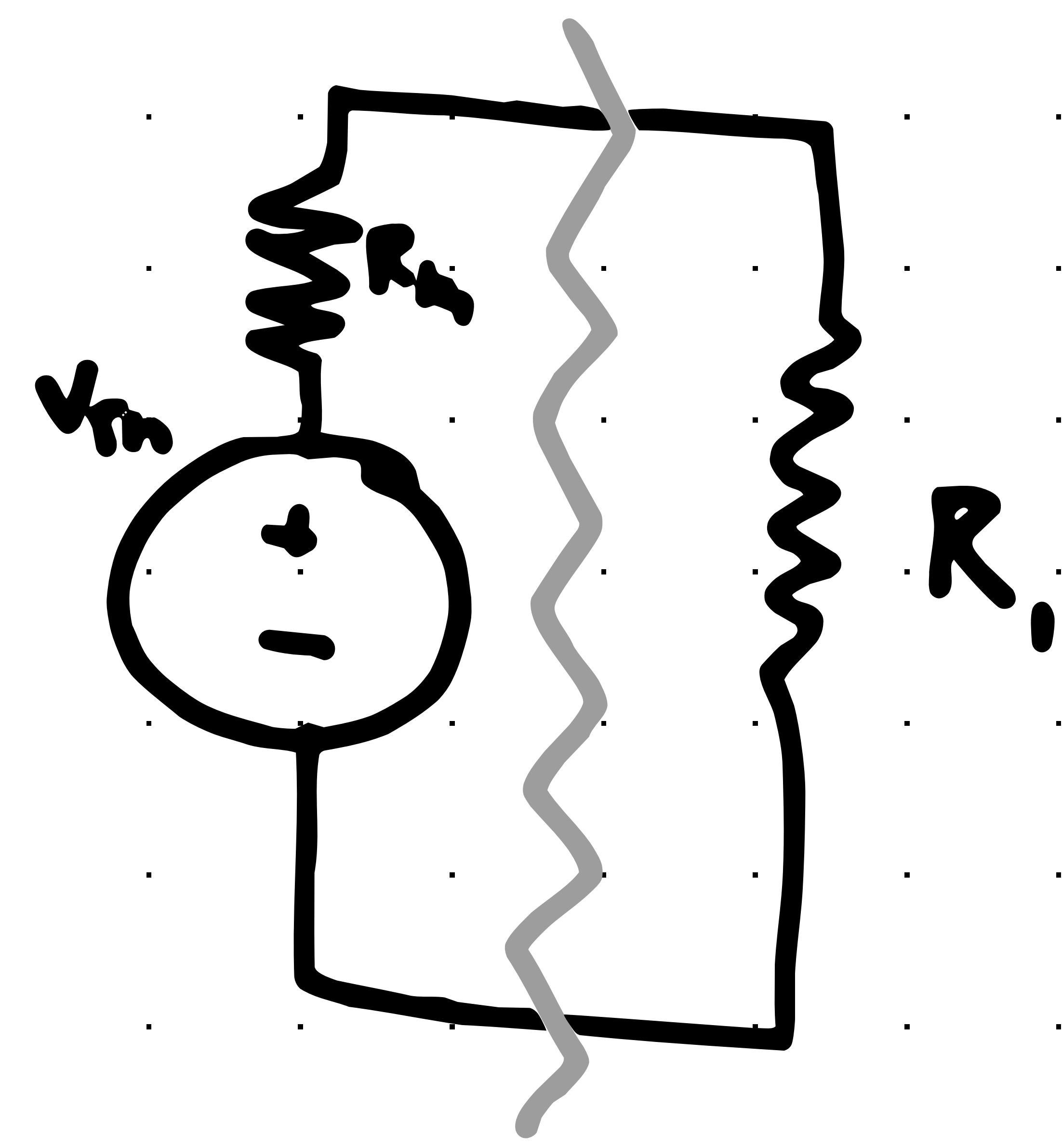
$$(V_o)^2 = (V_o' + V_o'')^2$$

5

Thevenin and Norton theorems:

Thevenin:

If you want to do analysis on R_1 for any circuit, you can shrink the circuit down to an equivalent circuit that looks like this.

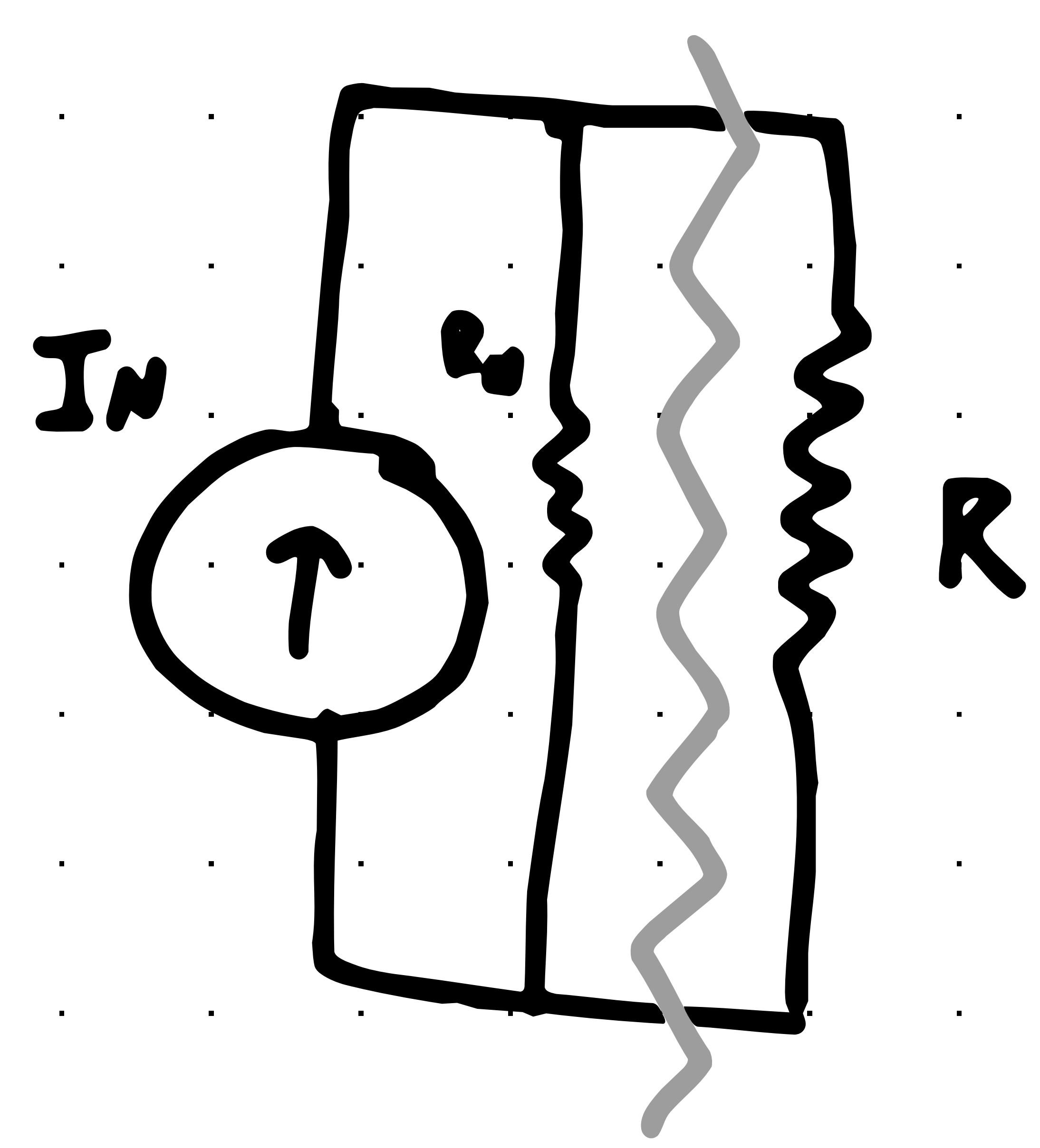


Voltage Source

Thevenin Equivalent

Norton:

If you want to o analysis on R_1 for any circuit, you can shrink the circuit down to an equivalent circuit that looks like this.



Current Source

Norton Equivalent

How do we Calculate $V_{Thevenin}$ and I_{Norton}?

$V_{Thevenin}$

1) Remove the Branch that you are looking to find V_{TH} accross.
2) Find the voltage accross the newly created open circuit.
3) $V_{open circuit} = V_{Thevenin}$

I_{Norton}

1) Remove the branch that you are looking to calculate Inorton accusss.
2) Short the newly created hole
3) Solve for current across the short.

$$I_{short circuit} = I_{Norton}.$$

To Calculate $R_{Th} = R_N$

1.

$$R_{TH} = R_{Norton} = \frac{V_{Thevenin}}{I_{Norton}}$$

* If you have $V_{Thevenin}$ and I_{Norton}

2.

Replace any independent voltage source by a short circuit and any independent current source by an open circuit

Then, use any voltage source (any value like 1, 10....) to inject a specific value in the circuit across the lumen

Haven't completed! Catch up from posted notes!