

5

Superposition Theorem

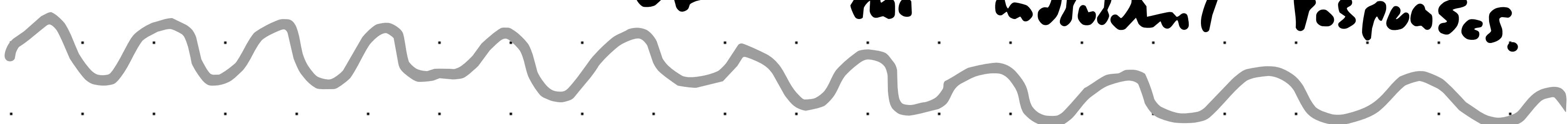
A linear Circuit excited by multiple

Sources will have a response which

is the sum

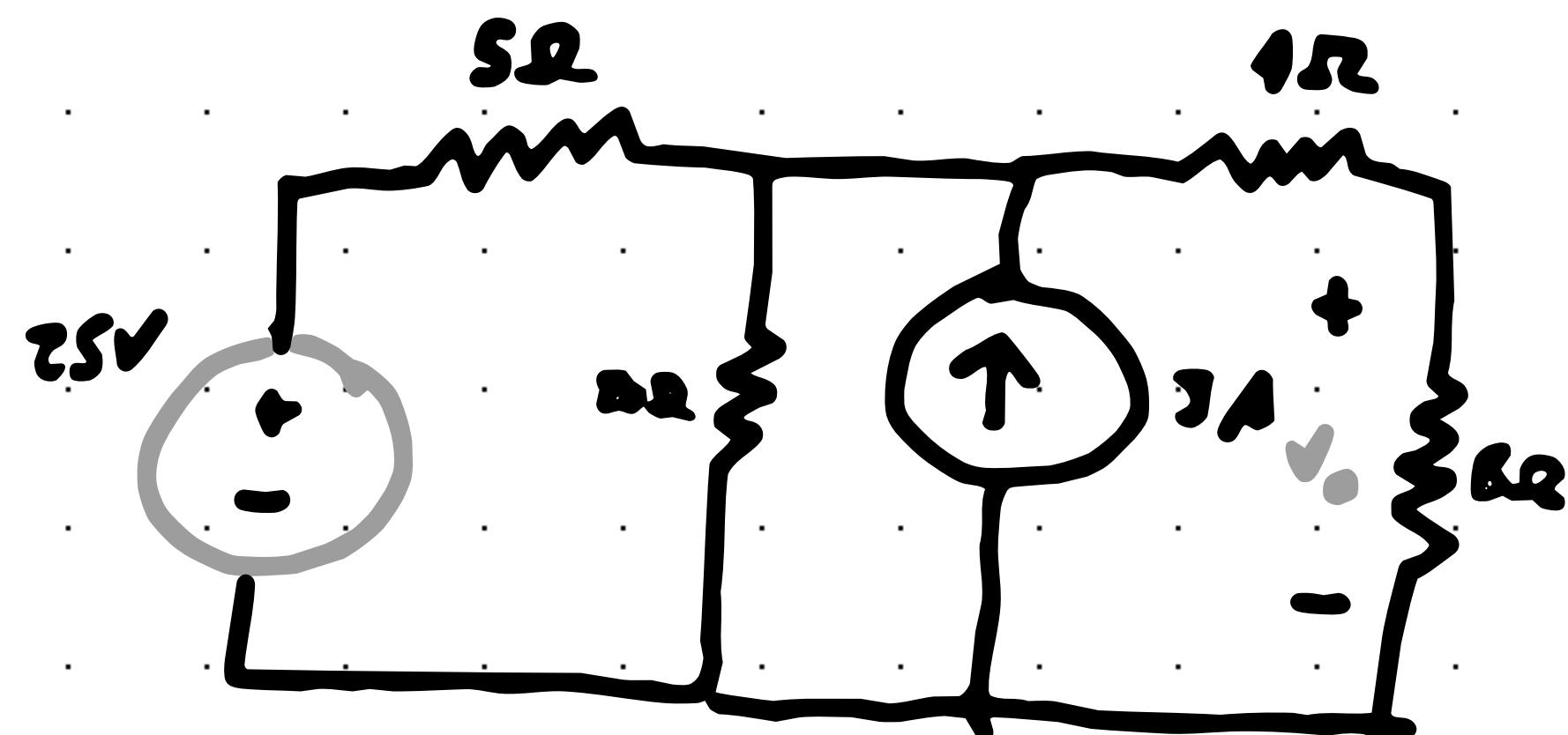
of

the individual responses.



Ex: Find V_o using the

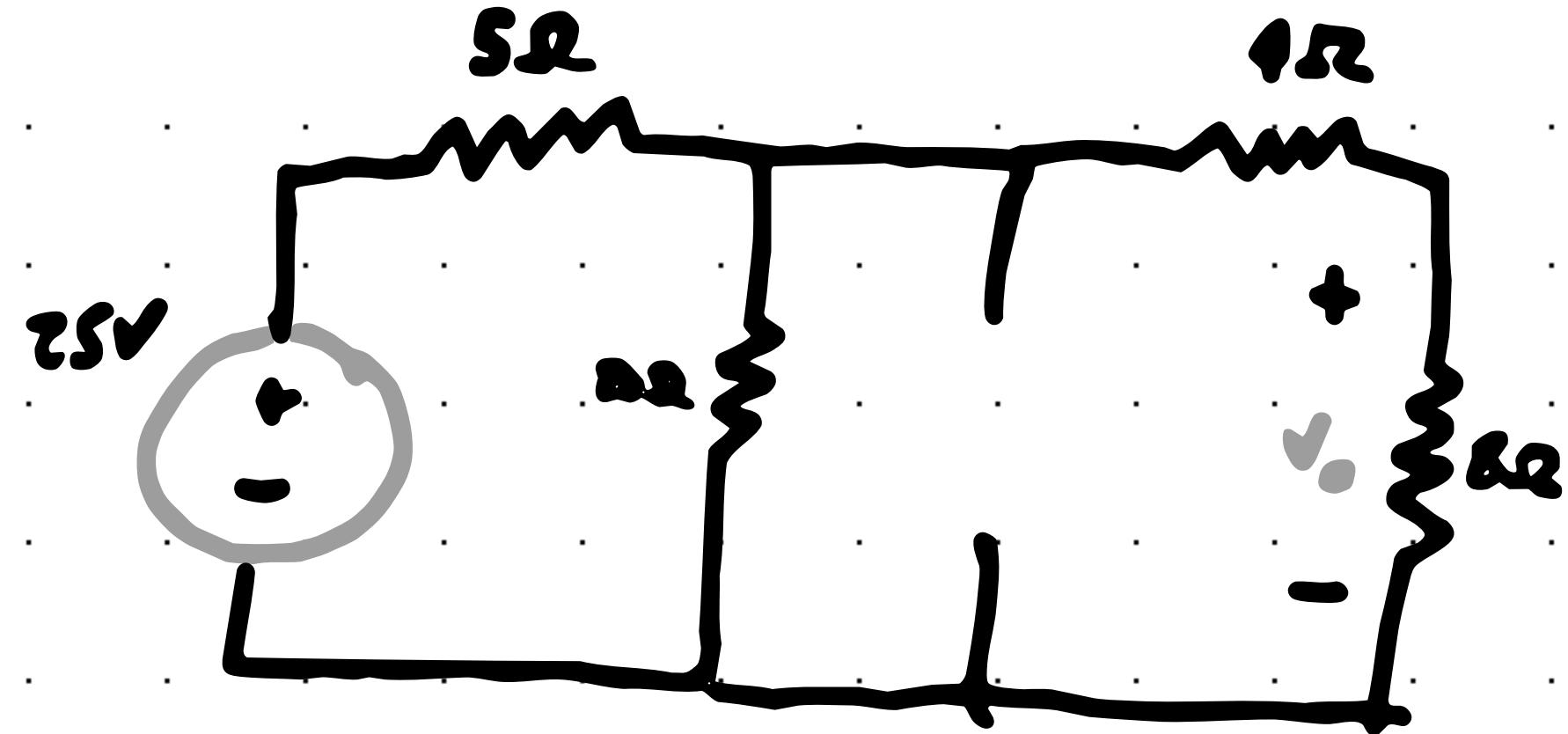
Superposition theorem



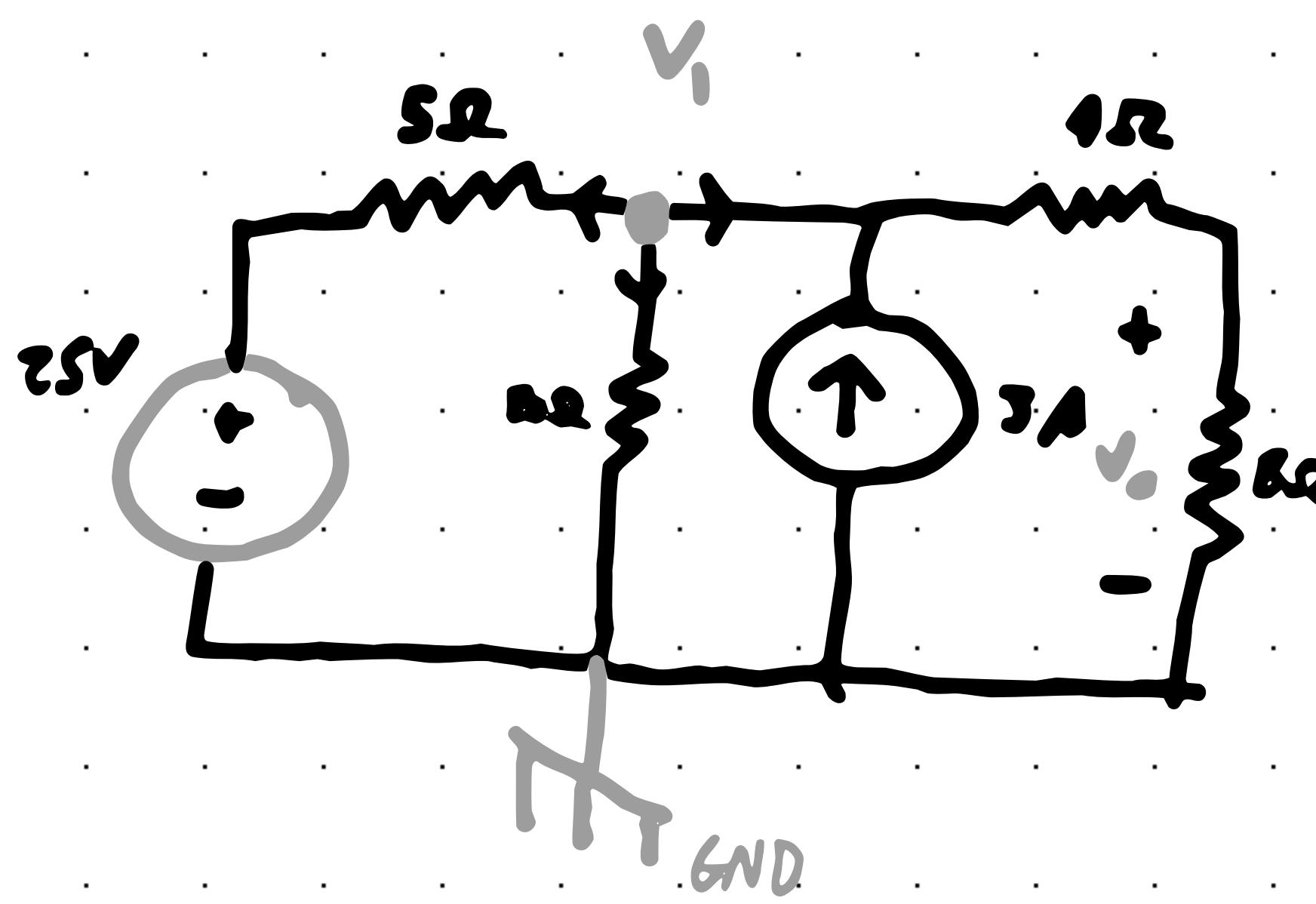
- Removing a Voltage Source requires a Short Circuit to be swapped in.
- Removing a Current Source requires an open Circuit to be swapped in.

Solution

Apply 25V, and
Current 3A



Let's begin by Solving with Nodal Analysis



$$\sum I = 0 \\ @ \text{ Node 1}$$

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

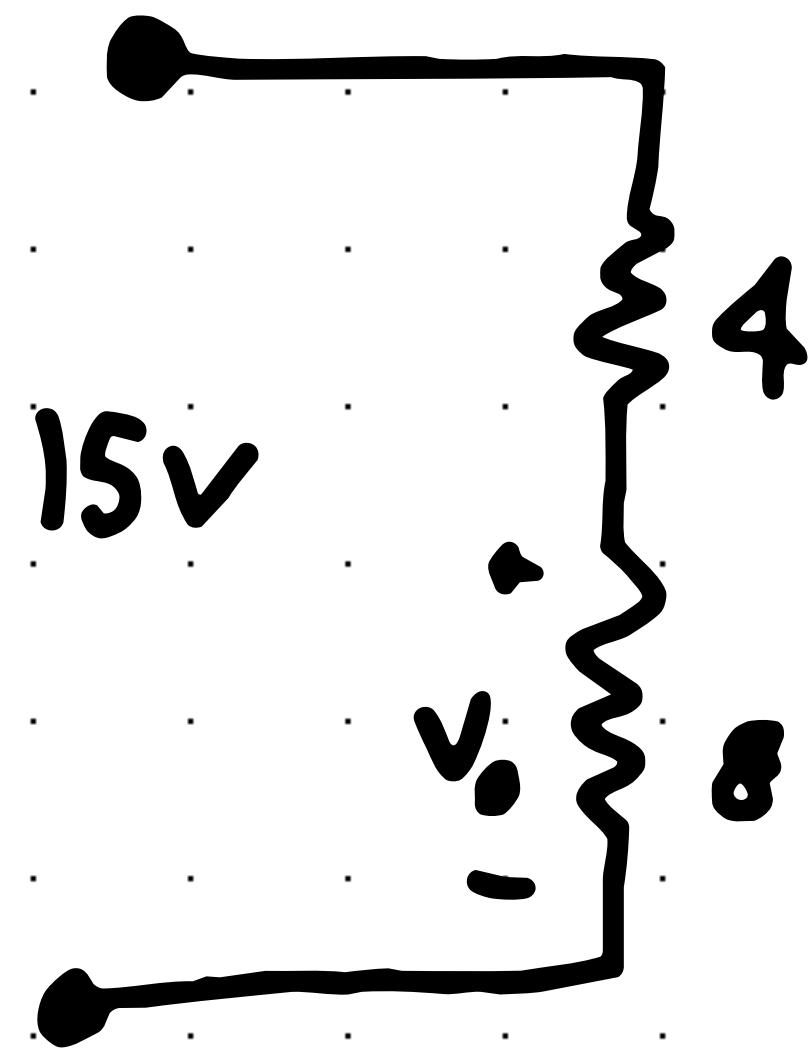
↑ Factor 1 and

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

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

Now, Let's Solve it

Using Voltage Divider



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

Note For High-Schools 😊

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

$$V = IR$$

(Voltage) (currents (current))

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

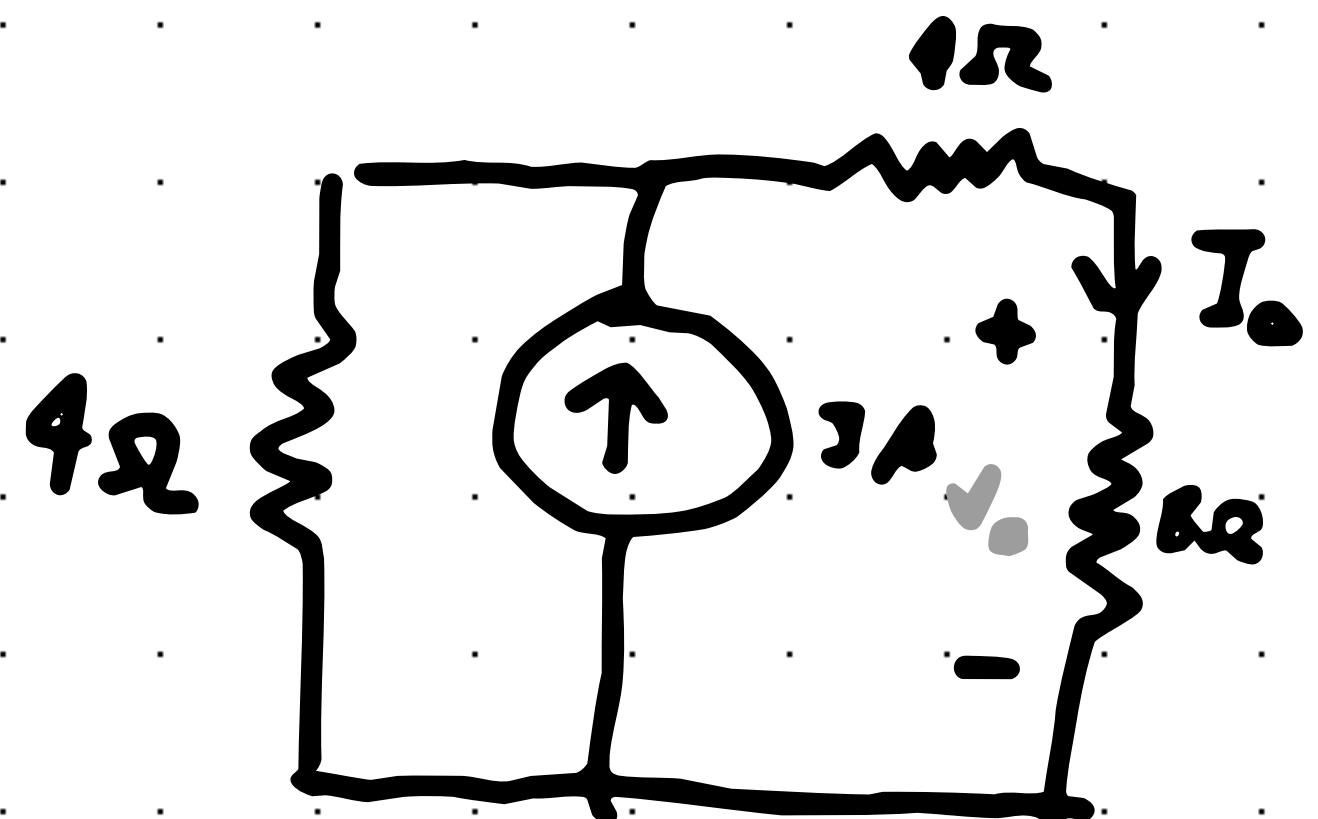
(You will see in PHYS 12)

Now, let's remove the Voltage Source instead!

OHM's Law!

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

(Parallel)



Using Current divider (Variace of Ohm's Law)

$$I_o = 3 \left(\frac{4}{4 + (9|8)} \right) = 0.75A$$

So,

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

$$V_o = V_o' + V_o'' + \boxed{10} + 6 = \boxed{16V}$$

Last Page

NOTE:

You Cannot Use these
Superpositions Created "V_{o'}" and
"V_{o''}" to Calculate Power.

$$P = \frac{V_o'^2}{R} = \frac{10^2}{8} = 125W$$

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

$$P = VI$$

$$P = \frac{V^2}{R}$$

but Linear!

$$P_{\text{Req}} \neq P' + P''$$

i.e.

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

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

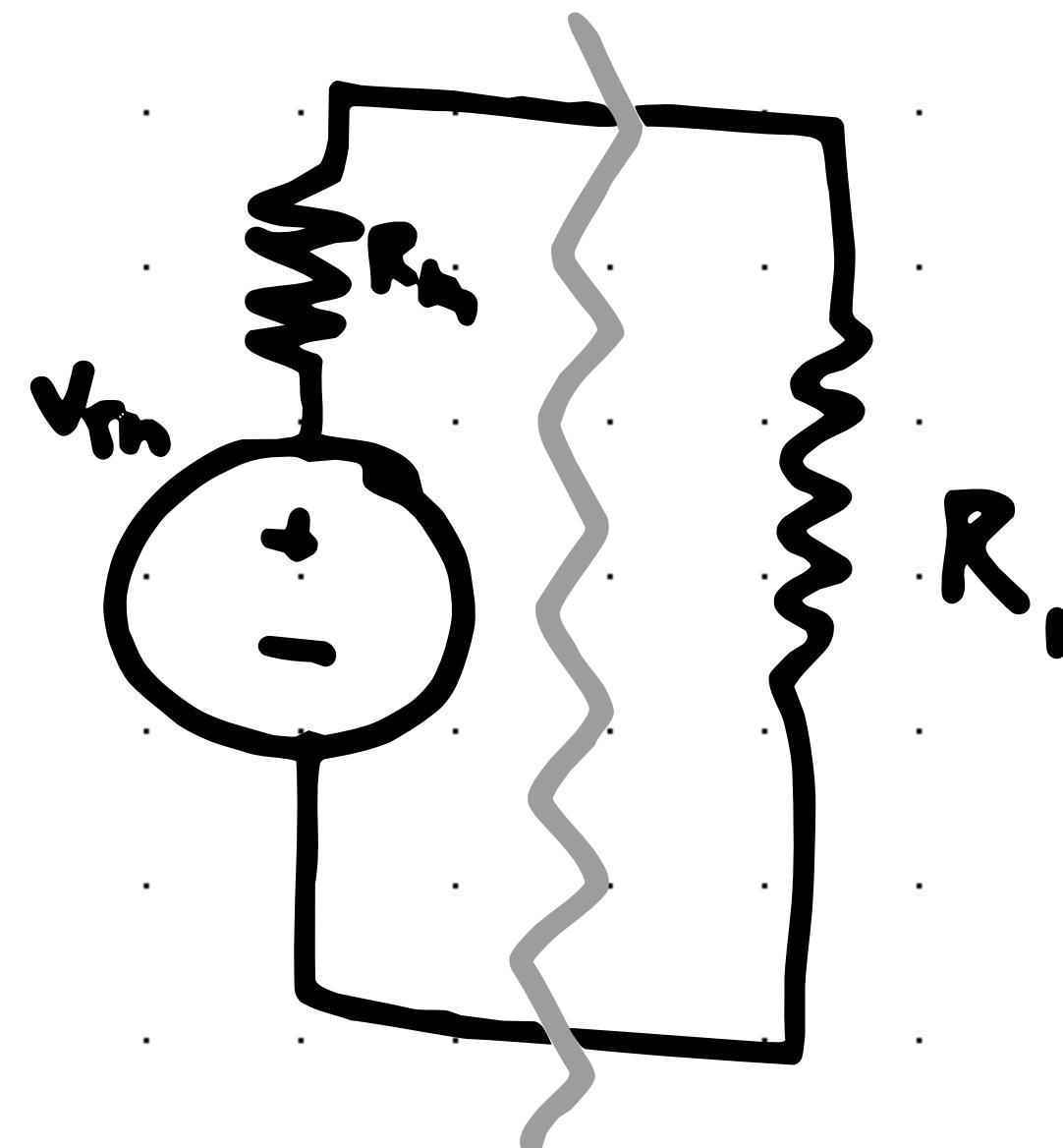
$$(V_o)^2 = (V_o' + V_o'')^2$$

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Thevenin and Norton theorems:

Thevenin:

If you want to do analysis on R_i for any circuit, you can shrink the circuit down to just one equivalent circuit like this.

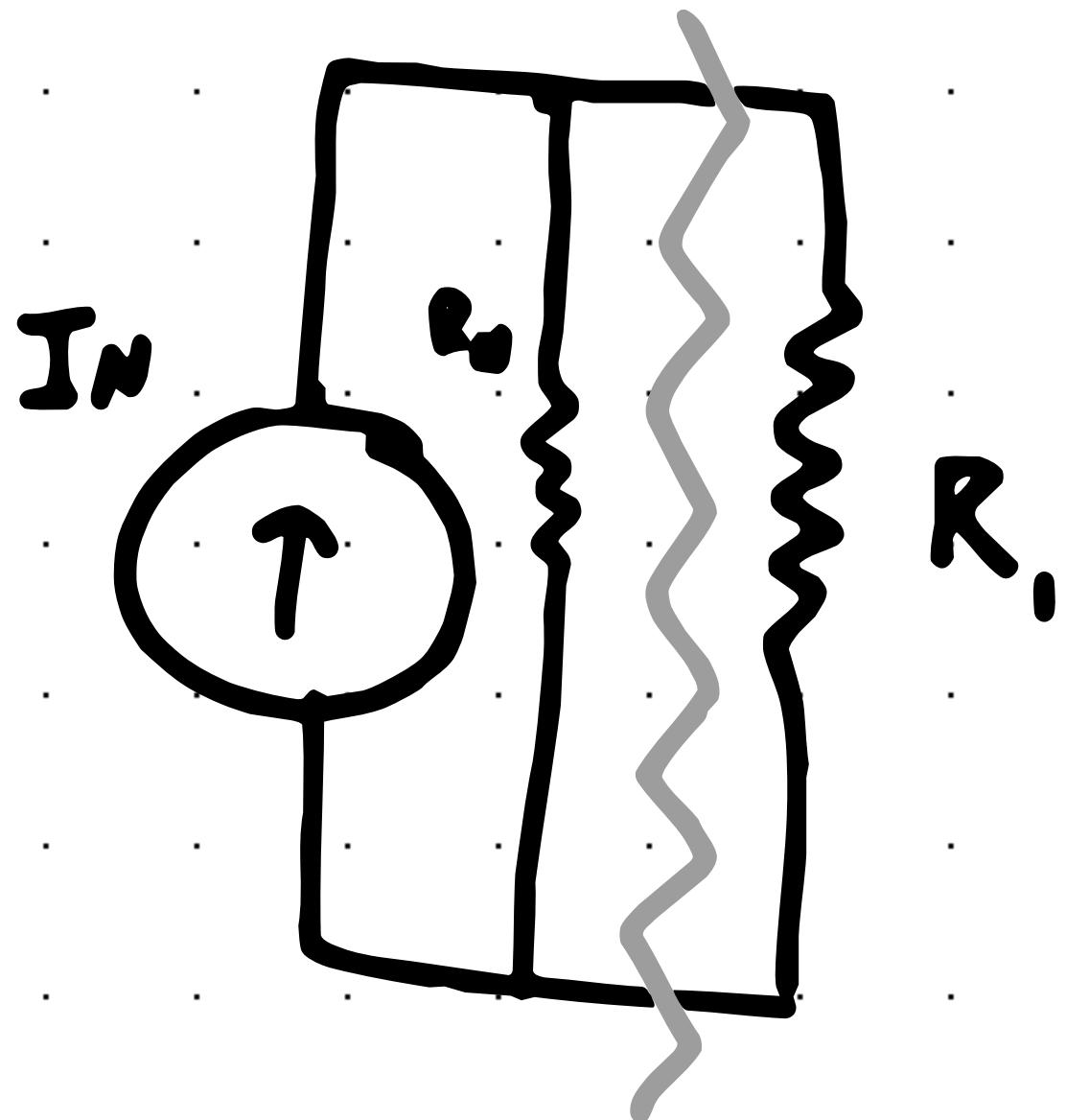


Voltage Source

Thevenin Equivalent

Norton:

If you want to do analysis on R_i for any circuit, you can shrink the circuit down to just one equivalent circuit like this.



Current Source

Norton Equivalent

How do We Calculate $V_{Thomson}$ and I_{Norton} ?

$V_{Thomson}$

- 1) Remove the branch that you are looking to find V_{TH} across.
- 2) Find the voltage across the newly created open circuit.
- 3) $V_{OpenCircuit} = V_{Thomson}$

I_{Norton}

- 1) Remove the branch that you are looking to calculate I_{Norton} across.
- 2) Short the newly created hole.
- 3) Solve for current across the short.

$$I_{ShortCircuit} = I_{Norton}$$

To Calculate $R_{Th} = R_N$

①

$$R_{Th} = R_{Norton} = \frac{V_{Th\text{ Norton}}}{I_{Norton}}$$

* If you have $V_{Th\text{ Norton}}$ 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 branch

Haven't Completed! Catch up from posted Notes: