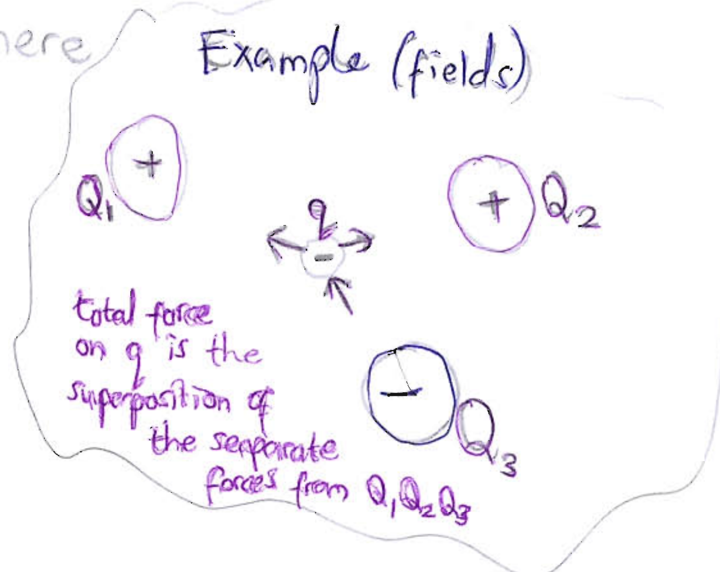
SUPERPOSITION

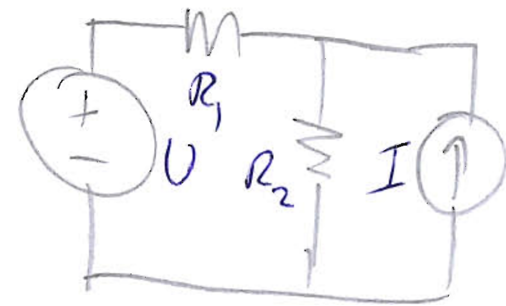
- a small but useful subtopic
- familiar from elsewhere



- applies to linear circuits

BASIC PRINCIPLE

- in a circuit with more than one independent source,
- solve the circuit for one of the sources at a time



- then add the solutions to find the solution for the complete circuit.

FURTHER POINTS

- doesn't really have to be "one at a time"
  (can do any groups as long as we handle each independent source just once) eg. with 5 sources, could solve for 3 of them together, then 1 then 1 — choose whatever is most useful)

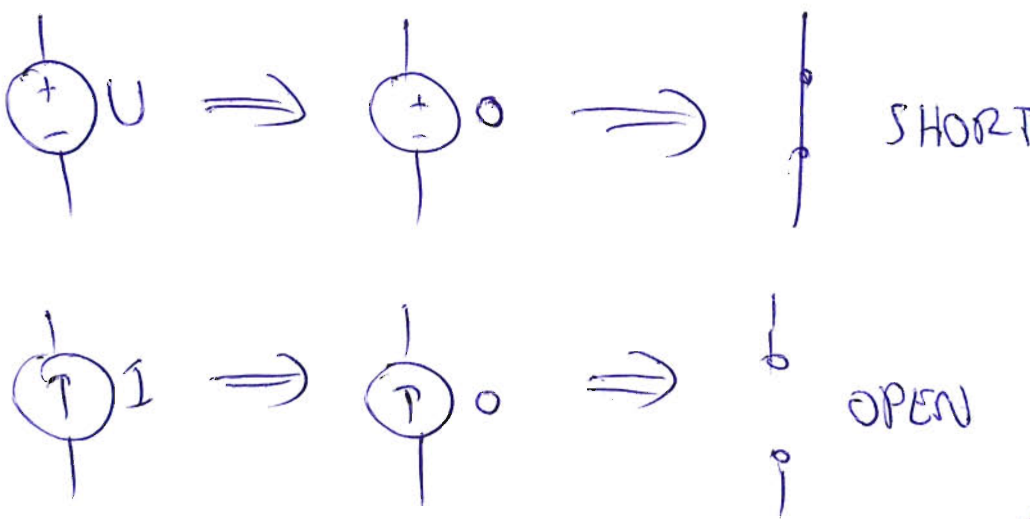
- main "**open question**" (until next page):
  What do we do with the **other sources** when solving for one?

- important "skill":
  need to be **careful** to keep track of what's being solved, and to add all solutions at the end

What do we do to the other sources when solving for one of them?

(independent sources)

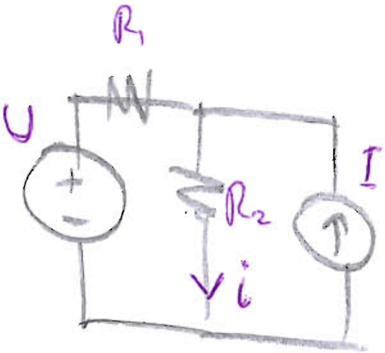
⇒ We SET THEM TO ZERO



IMPORTANT

"obvious" but a common error is to confuse these cases!!

EXAMPLE: let's try it with the earlier circuit.

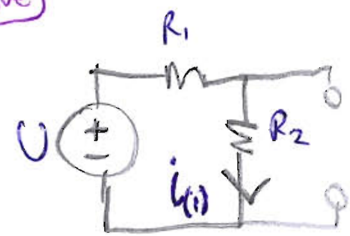


"find i"

There are two independent sources.

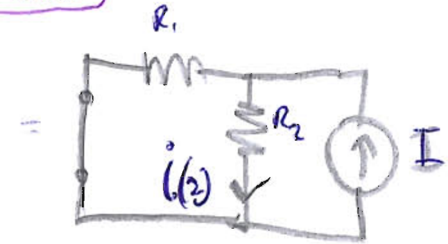
To use superposition, we solve two different circuits (or "superposition states"):

U active



$$i_{(1)} = \frac{U}{R_1 + R_2}$$

I active



$$i_{(2)} = \frac{I R_1}{R_1 + R_2}$$

Then add the results:

$$i = i_{(1)} + i_{(2)} = \frac{U}{R_1 + R_2} + \frac{I R_1}{R_1 + R_2} = \frac{U + I R_1}{R_1 + R_2}$$

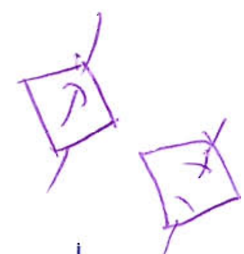
the solution, by superposition

So, that was quite an easy idea!

- sometimes good for getting solutions
- sometimes not as easy as e.g. nodal analysis
- particularly useful as a **concept** for **proofs**, even if not always best for quick solutions.

Now the usual question:

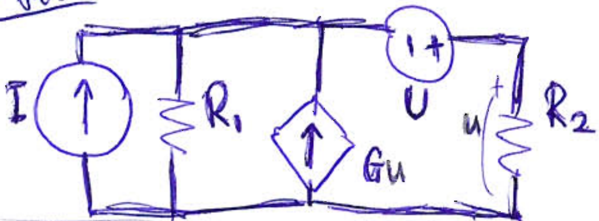
What about DEPENDENT SOURCES?



Answer: the usual approach is to leave these active in the circuit in each calculation (like the resistors) —
(we add the solutions of independent sources acting separately)

EXAMPLE with DEPENDENT SOURCE and superposition

complete



'I' active

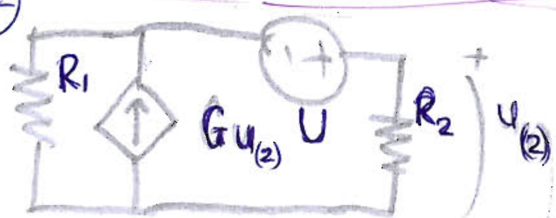
$$u_{(1)} = \left(I + G u_{(1)}\right) \frac{R_1 R_2}{R_1 + R_2}$$

$$u_{(1)}\left(1 - \frac{G R_1 R_2}{R_1 + R_2}\right) = \frac{I R_1 R_2}{R_1 + R_2}$$

$$\boxed{u_{(1)} = \frac{I R_1 R_2}{R_1 + R_2 - G R_1 R_2}}$$

solution for state 1

'U' active



$$\frac{u_{(2)}}{R_2} + \frac{u_{(2)} - U}{R_1} - G u_{(2)} = 0 \leftarrow (KCL)$$

$$R_1 u_{(2)}\left(\frac{1}{R_1} + \frac{1}{R_2} - G\right) = U$$

$$\boxed{u_{(2)} = \frac{U R_2}{R_1 + R_2 - G R_1 R_2}}$$

solution for state 2

add

(continued)

$$U = U_{(1)} + U_{(2)} = \frac{(U + IR_1)\,R_2}{R_1 + R_2 - G R_1 R_2}$$

That might seem neat.

But in this case, nodal analysis (KCL) on the whole circuit including both independent sources would probably have been quicker and easier ... try it!

(Just add a "−I" term in the start of the state (2) solution on the previous page!)