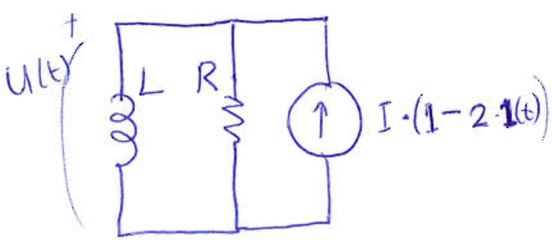
CONTINUITY (the second part of topic 7)

We're still thinking of complicated circuits: many C & L, etc.

Now we go beyond equilibria, to the case where a **sudden change** has happened to a circuit that had **known values of capacitor voltages and inductor currents before the change**;

Typically this means there **was** an equilibrium, and then something happened to **disturb** it (a switch, or step).

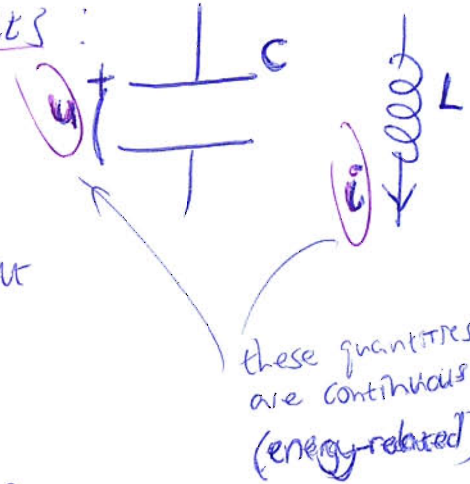


Here we can find $u(0^-)$, $u(\infty)$ } equilibrium solutions

but what about $u(0^+)$ } ⟸ **NOW**: continuity

or $u(t)$ $t>0$, $u(2s)$ etc.] next week (for ① C or L components)

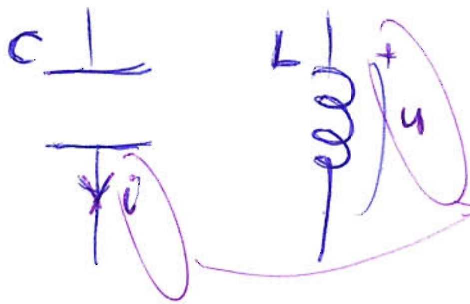
CONTINUITY is about <u>CONTINUOUS VARIABLES</u> :



We know that these do not change without energy having been moved in or out of the component... it takes <u>time</u> ... So immediately after a change in the circuit, the continuous variables still have the same value (practically) as before the change.

$\Longrightarrow$ If we know the values of continuous quantities before a change, then we know the capacitor voltages and inductor currents just after the change, too!

What about the other quantities?



NOT continuous

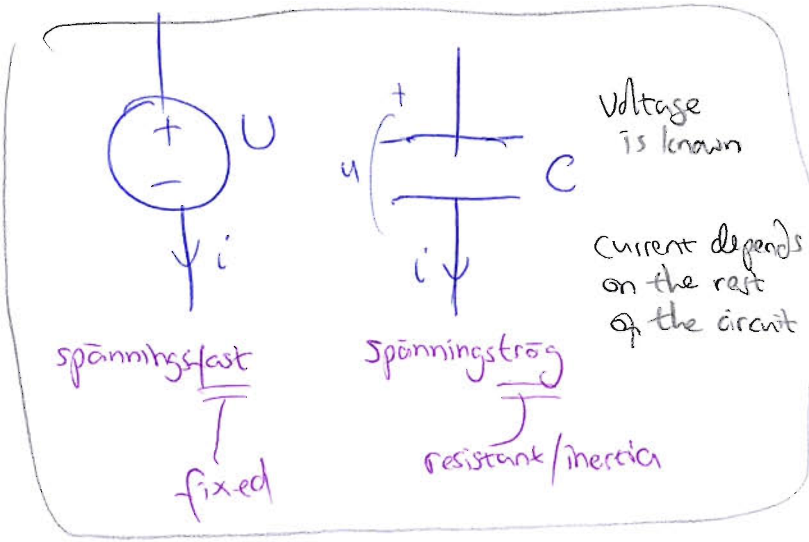
(they determine how quickly the continuous quantities change: $\frac{i_c}{C} = \frac{dv_c}{dt}$)

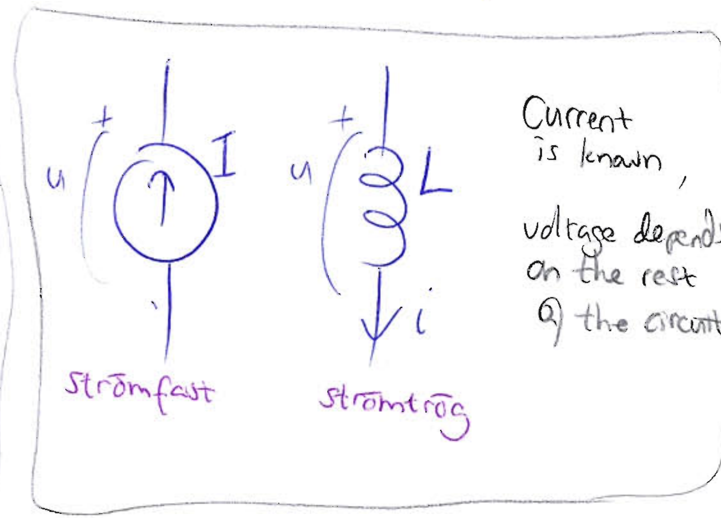
We can't say anything about these based on what they were before the change -- they can jump (step).

<u>But</u> if we solve the rest of the circuit based on the known continuous quantities, we can solve for these.

It sounds like sources !!
{ know <u>one</u> quantity fully
{ do <u>not</u> know the <u>other</u> — rest of circuit decides.

"In a short time {just after a change} it's hard to distinguish a big inertia from a fixed object" (i.e. tröghet från fasthet)





So we can replace a capacitor charged to u, by a source "u",
Similarly, we can replace an inductor with current i by a source "i"

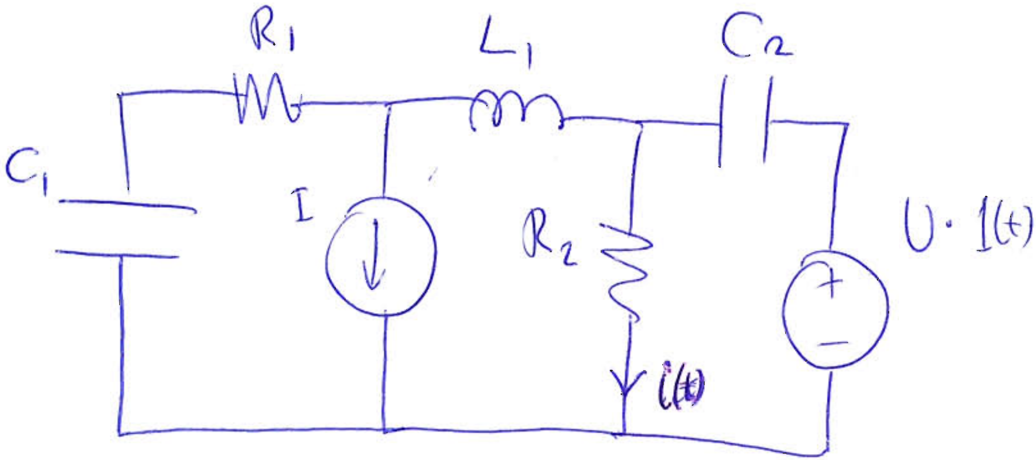
* This is only true for the short times before significant change happens!!

Rather like last time (equilibrium) "That's all there is to it".

It's not a hard process to describe, for doing calculations of circuit quantities after a step change, based on continuity!

The difficulties are in the dc circuit solutions, and in carefully keeping track of the continuous variables that determine the sources that can replace C and L components just after a change.

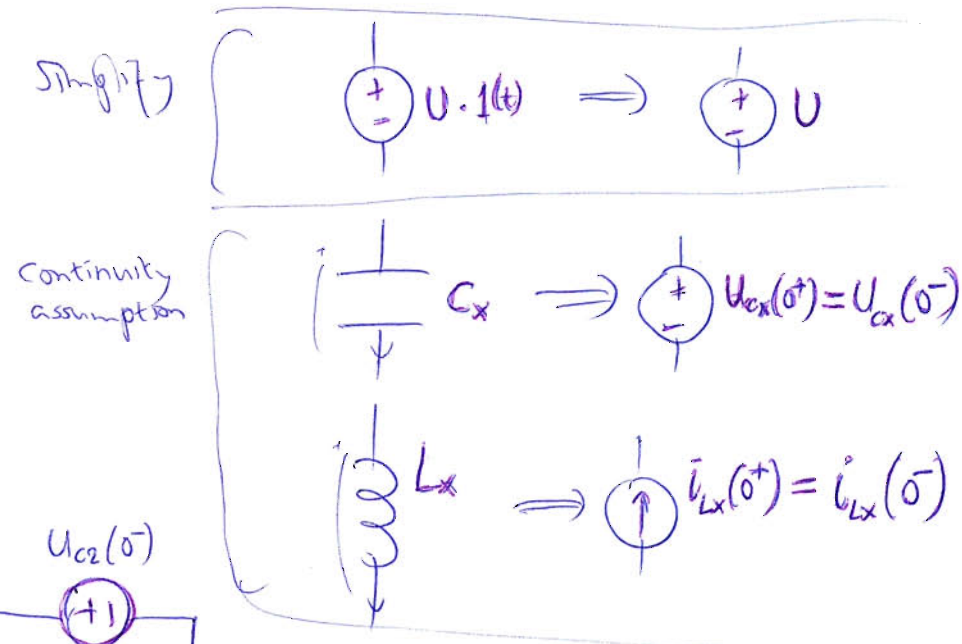
Example

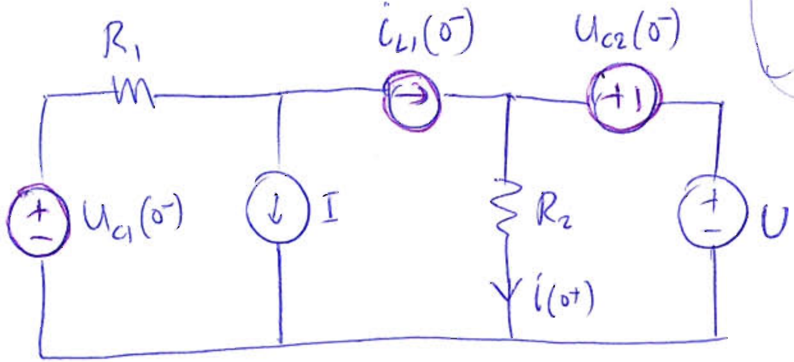


"find $i(0^+)$" (0^+ is the time just after the step function)

We can't just consider the circuit diagram at $t = 0^+$.
It depends on the stored energy from the <u>earlier</u> times.

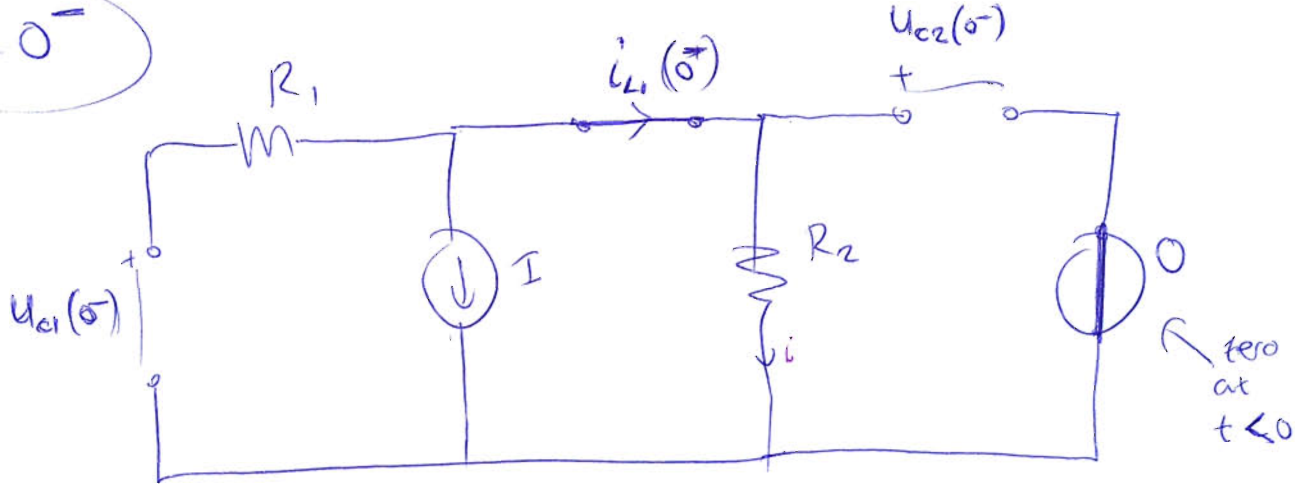
for $t = 0^+$ we can draw the circuit with substitutions:





Now find the equilibrium values ($t=0^-$) of continuous quantities, which will give the source values (of sources replacing C & L) in the $t=0^+$ circuit.

$t=0^-$



$i_{L1}(0^-) = -I$ (KCL)

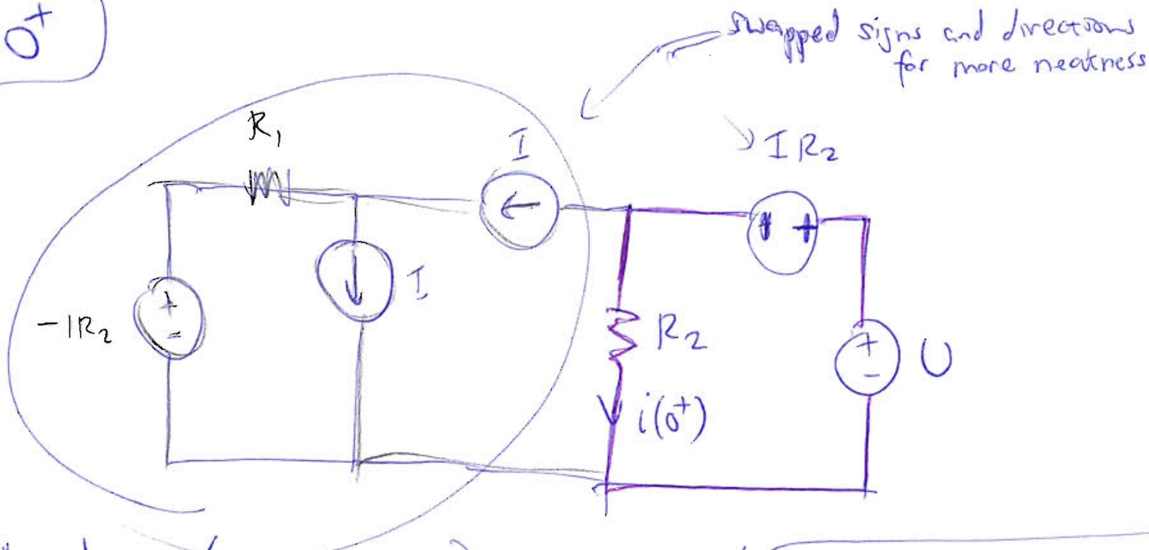
$u_{C1}(0^-) = -IR_2$ (Ohm, KVL)

$u_{C2}(0^-) = -IR_2$ (Ohm, KVL)

Actually if we look at the $t=0^+$ circuit carefully we see that only $u_{C2}(0^+)$ is relevant to $i(0^+)$ ... we could have ignored u_{C1} and i_{L1}

Putting this solution back, we get

$t = 0^+$



not relevant to $i(0^+)$, (as R_2 is given a fixed voltage by the source U and capacitor C)

$$i(0^+) = \frac{U - IR_2}{R_2}$$