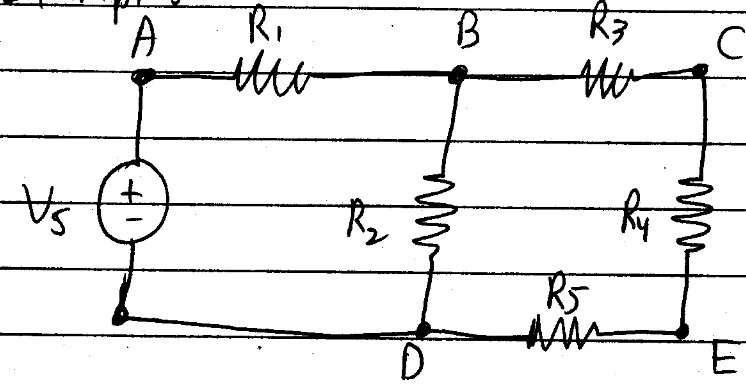
As stated in text:

KCL: If a ckt contains N nodes, there are N-1 independent KCL equations.

KVL: If a ckt contains E 2-terminal elements and N nodes, there are only E-N+1 independent KVL equations

Examples:

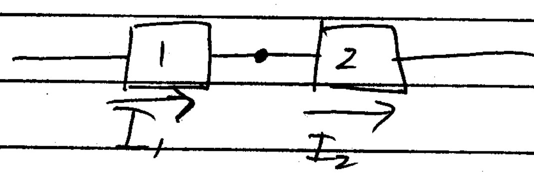


How many elements? — $6 = E$
How many nodes? — $5 = N$

KCL Equations: $N-1 = 5-1 = \underline{4}$

KVL Equations: $E-(N-1) = 6-4 = 2$

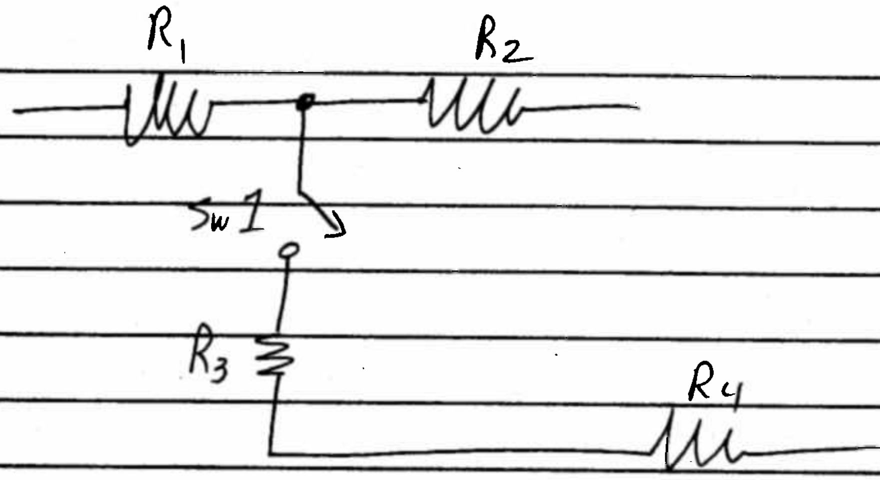
I have already told you about "series connections":



$I_1 = I_2$

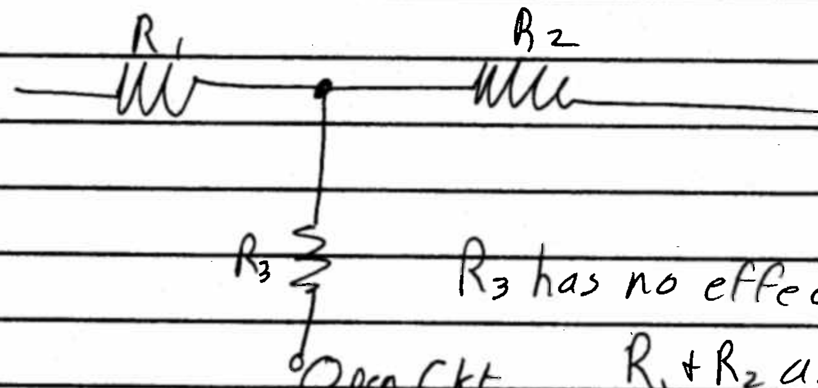
"Connected to a "common node to which no other element with current flowing through it is connected," is how the book says it.

Eg,



When SW1 is <u>open</u>, R_1 + R_2 are in series.

When SW1 is <u>closed</u>, R_1 + R_2 are <u>not</u> in series

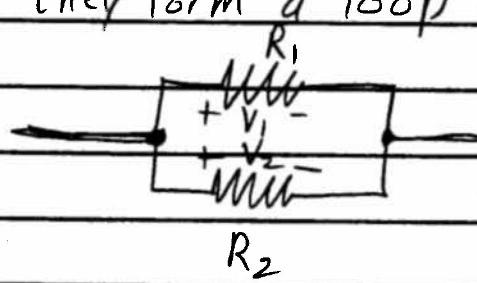


R_3 has no effect,

R_1 + R_2 are in series.

We say that elements are in <u>parallel</u>

when they form a loop by themselves:

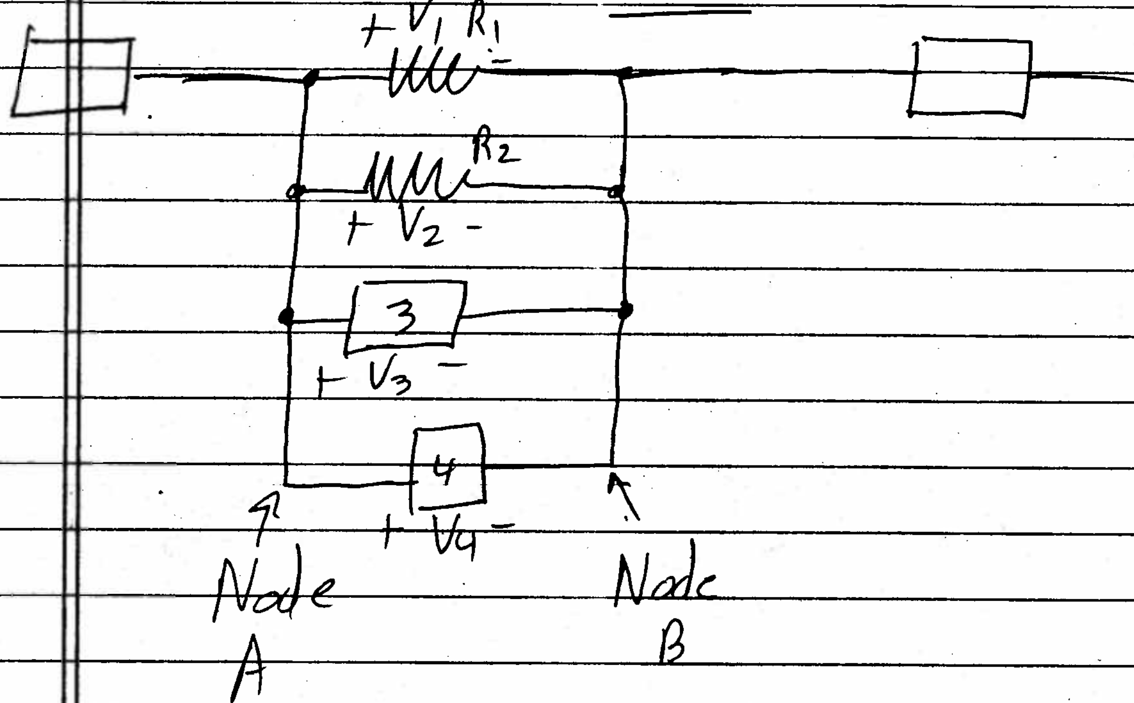


KVL: $+V_1 - V_2 = 0$

$V_1 = V_2$

Another way of saying this:

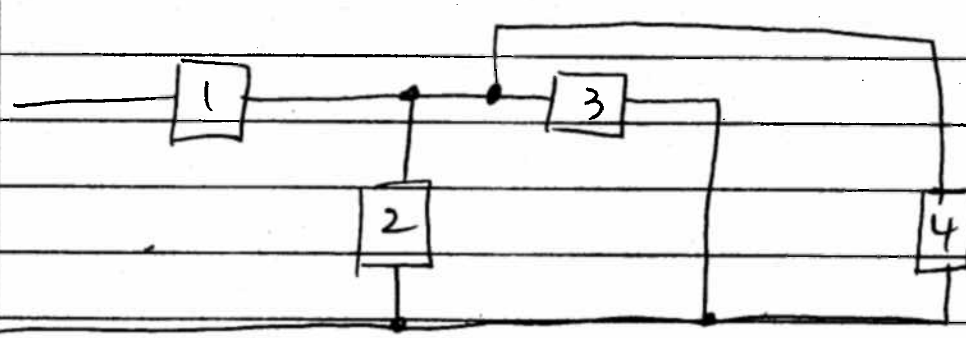
When <u>both</u> ends of 2 or more elements are connected to the same 2 nodes:



$R_1, R_2, 3, + 4$ are all in parallel:

$$V_1 = V_2 = V_3 = V_4$$

Sometimes the do not look like it:

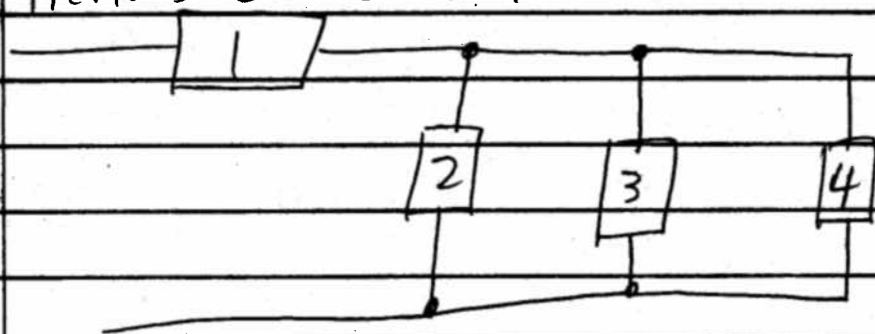


Sometime we will write this as

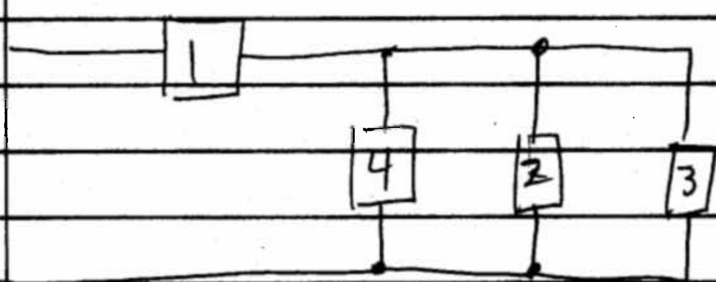
1 inseries with $2 /\!/ 3 /\!/ 4$

Note I can bend + stretch wires with no effect, as long as the do not connect to other things. Can also slide connections.

Previous ckt can be:

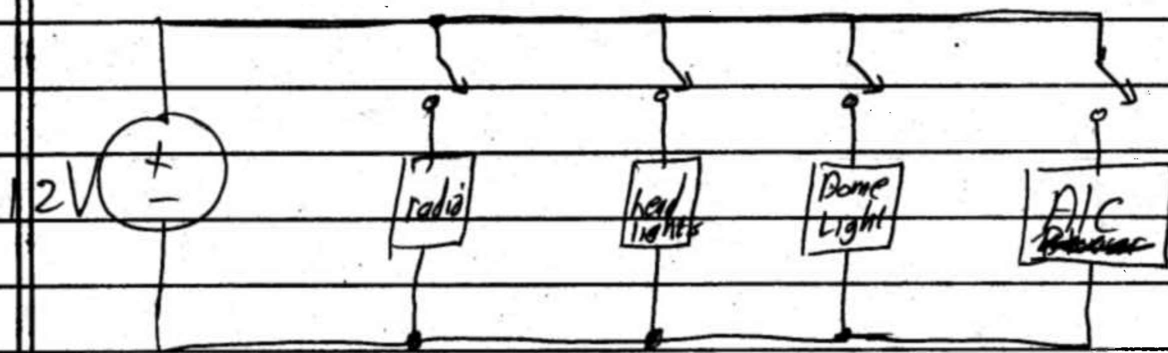


or



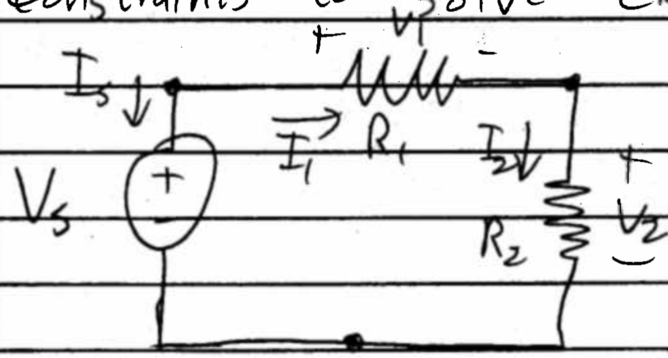
etc.

Parallel ckts, in some ways, have minimal effect on each other, and so are used to good effect, say in your car:



~~You should do examples in text + H.W.~~

We will now combine Element + Ckt Constraints ~~to~~ "solve" ckts.



$N = 3$ KCL: 2
$E = 3$ KVL: 1

$R_1 + R_2$ are in series, so $\underline{I_1 = I_2}$

$V_s + R_1$ are in series, but I_s is opposite in direction: $I_1 + I_s = 0$

$\underline{I_s = -I_1}$

Let $I_1 = I_2 = -I_s = I$

Write KVL: $+V_1+V_2-V_s=0$

$$V_1+V_2=V_s \qquad \text{Ckt Constraint}$$

Ohm's Law $\quad V_1=R_1I_1 \;+\; V_2=R_2I_2 \qquad$ Element

$\qquad\qquad\qquad\; =R_1I \qquad\quad =R_2I \qquad$ constraints

So $\quad R_1I+R_2I=V_s$

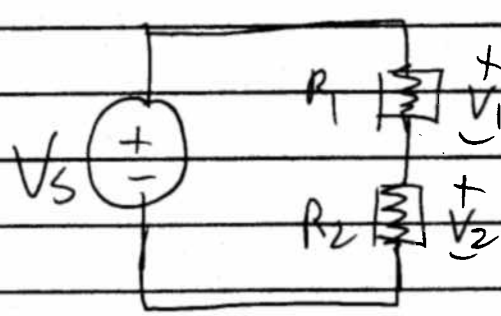
$$(R_1+R_2)I=V_s \longrightarrow$$ looks like Ohm's Law with $R_{eq}=R_1+$

$$I=\frac{V_s}{R_1+R_2} \qquad V_s=R_{eq}I$$

Now $\quad V_1=R_1I=R_1\left(\frac{V_s}{R_1+R_2}\right)=\frac{R_1}{R_1+R_2}V_s$

and $\quad V_2=R_2I=\frac{R_2}{R_1+R_2}V_s$

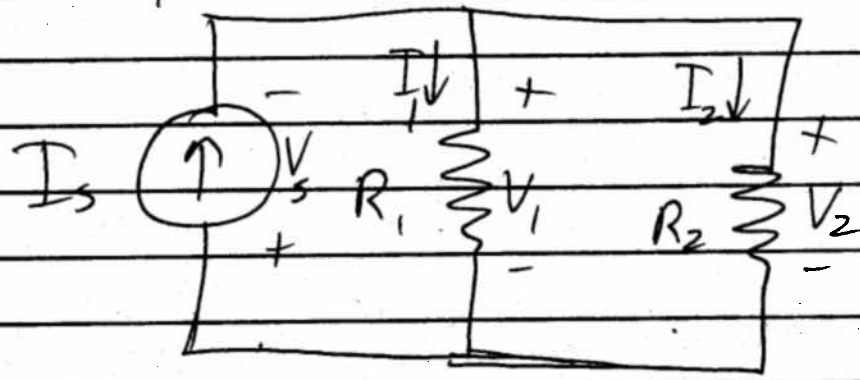
Example of Voltage Division:



KVL: $V_1+V_2=V_s$

We divide the source voltage between the 2 ~~elements~~ Resistors

Simlarly:



$N=2: KCL = 1$
$E=3, KVL = 2$

$$V_1 = V_2 = -V_s = V$$

KCL @ top: $-I_s + I_1 + I_2 = 0$

$$I_1 + I_2 = I_s$$

$$\frac{V}{R_1} + \frac{V}{R_2} = I_s$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) V = I_s$$

$$\left(\frac{R_2 + R_1}{R_1 R_2}\right) V = I_s$$

$$V = \frac{R_1 R_2}{R_1 + R_2} I_s$$

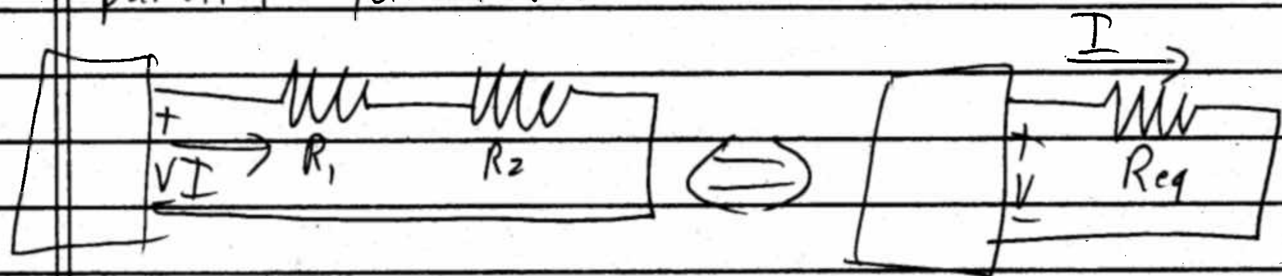
looks like Ohm's Law with $R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

$$I_1 = \frac{V}{R_1} = \frac{1}{R_1}\left[\frac{R_1 R_2}{R_1 + R_2} I_s\right] \quad \text{and} \quad I_2 = \frac{V}{R_2}$$

$$I_1 = \frac{R_2}{R_1 + R_2} I_s \qquad\qquad = \frac{R_1}{R_1 + R_2} I_s$$

This is called Current Division: Given a Current Source and 2 parallel resistors, how ~~much~~ is the Source Current divided between the 2 resistors?

I have already alluded to series + parallel equivalence:



R_{eq} is "equivalent" to R_1+R_2 if, for the same voltage V across them the same current I flows thru them.