As we did for capacitors, we will do for Resistors ①

Capacitors $Q = CV$ Resistors $IR = V$

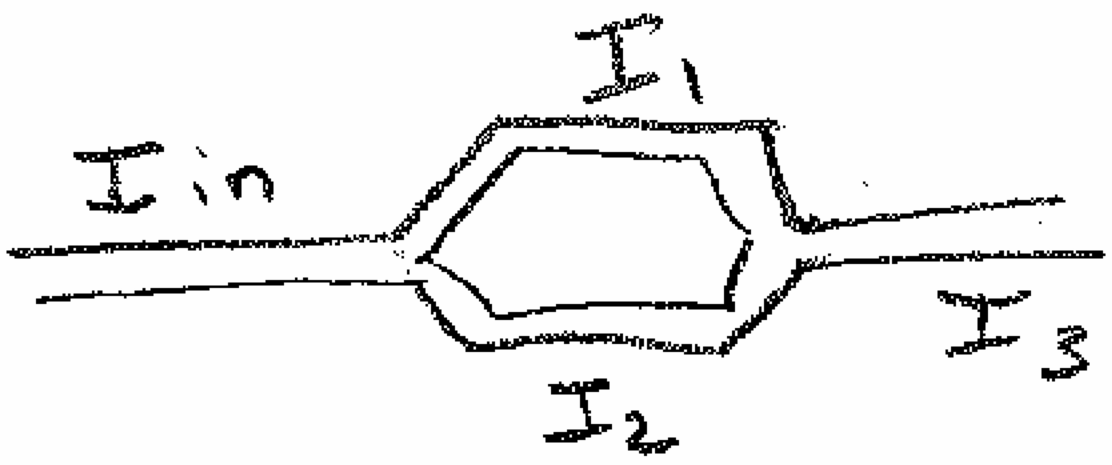
or

$I = \left(\frac{1}{R}\right)V$

Expect $\frac{1}{R}$ to behave like C?

consider

current conservation = no build up of charge in steady state flow. We've seen charge build up on capacitors & we'll get to dealing with those in a circuit too in a bit.



$I_3 = I_{in}$

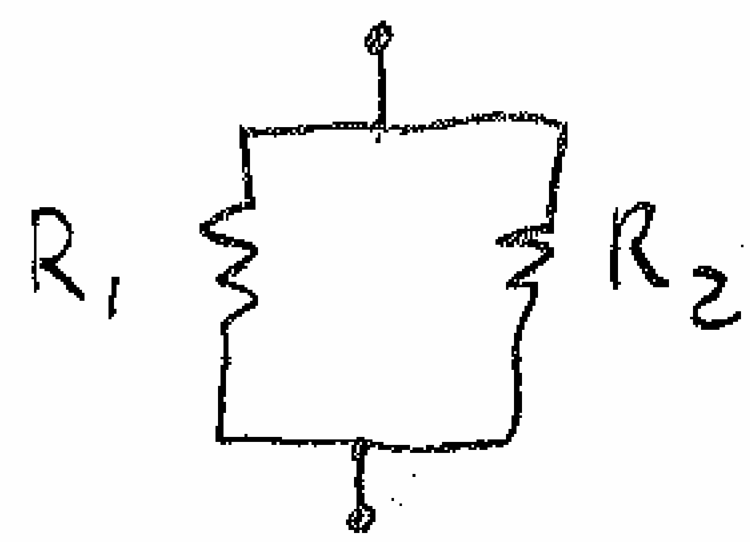
$I_{in} = I_1 + I_2$

$I_3 = I_1 + I_2$

Resistors in series same I

[capacitors in series same Q!]

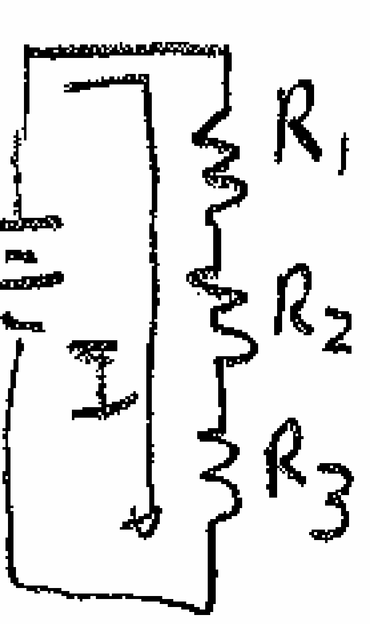
Resistors in Parallel same V



(same deal for caps ΔV same)

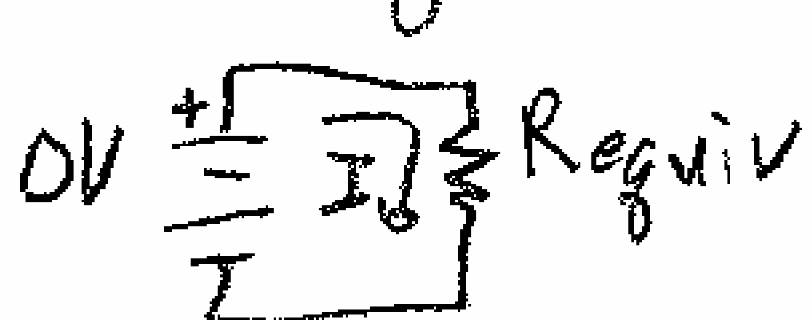
We've just chosen a different convention

series

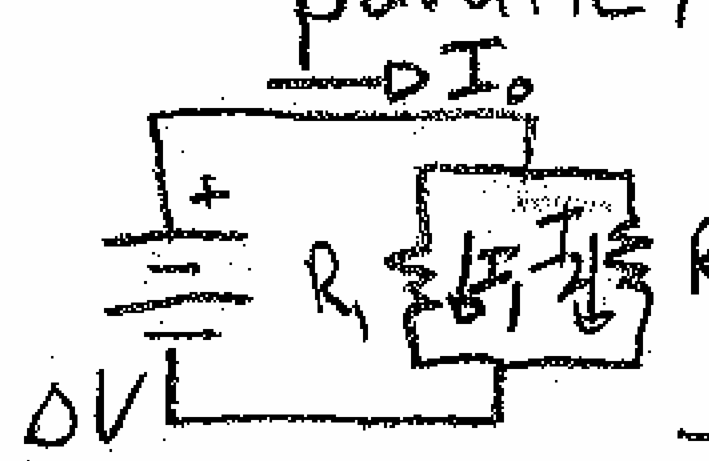


$IR_1 + IR_2 + IR_3 = \Delta V$

$I\underbrace{(R_1 + R_2 + R_3)}_{R_{equiv}} = \Delta V$



parallel

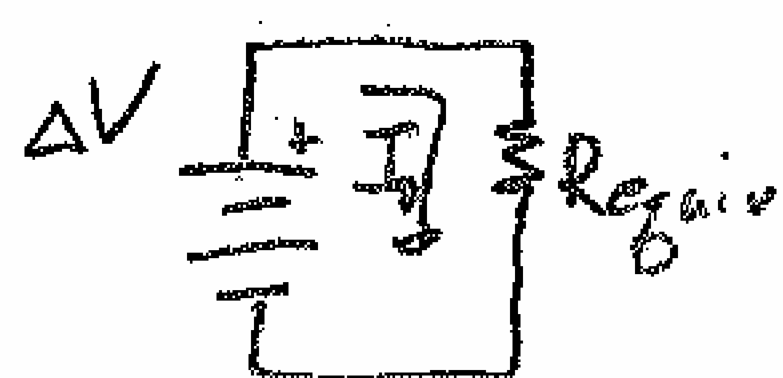


$\Delta V = I_1 R_1$

$\Delta V = I_2 R_2$

$I_0 = I_1 + I_2$

$I_0 = \frac{\Delta V}{R_{equiv}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2}$



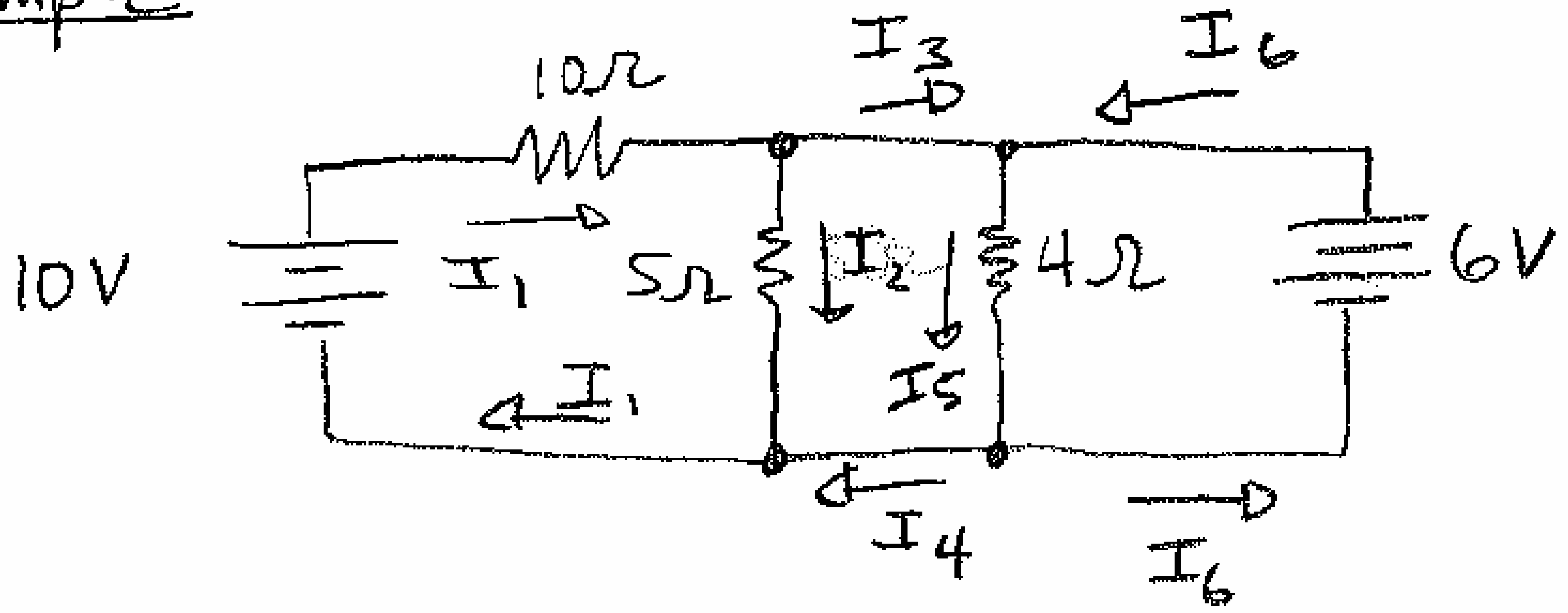
$\frac{1}{R_{equiv}} = \frac{1}{R_1} + \frac{1}{R_2}$

The methods we've been using to solve these problems are sometimes called kirkoffs rules

$\sum_{into} I = 0$ sum of currents into a junction = 0 (or battery!)

$\sum_{loop} V = 0$ sum of voltages around a loop = 0

Example



Typically with these problems, you get a set of equations & unknowns. (We could make this simpler but we'll do it the hard way 1st!)

3 loops

(b) $10V - I_1(10\Omega) - I_2\,5\Omega = 0$

(c) $I_2\,5\Omega - I_5\,4\Omega = 0$

(a) $6V + I_1\,10\Omega - 10V = 0$

make sure you get all the R's & V's

(c) $I_6 + I_3 - I_5 = 0$

$I_5 - I_6 - I_4 = 0$

(these imply $I_3 = I_4$)

(d) $I_1 - I_2 - I_3 = 0$

$I_2 + I_4 - I_1 = 0$

(these too!)

need at least 6 equations to find all the currents

(a) is easiest $I_1\,10\Omega = (10V - 6V) \Rightarrow I_1 = 0.4A$

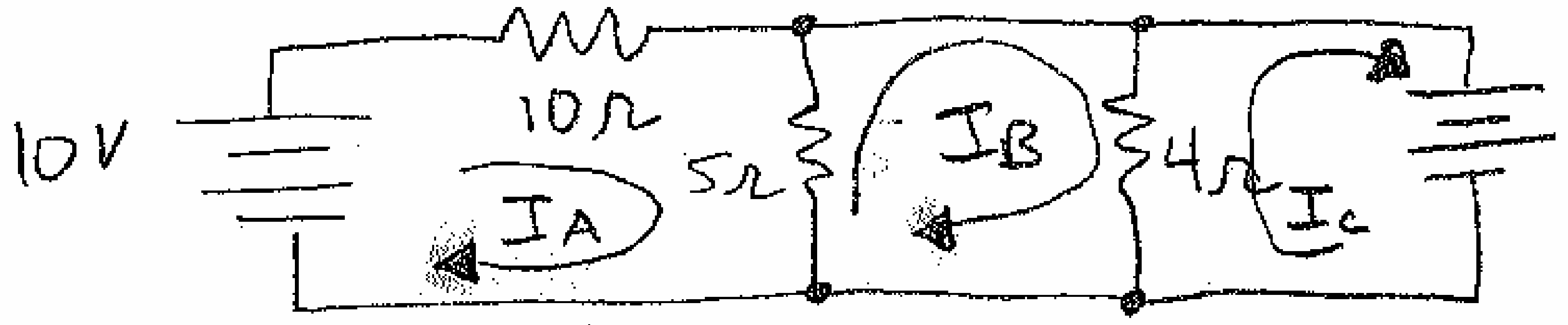
(b) $10V - 0.4A(10\Omega) - I_2 5\Omega = 0 \Rightarrow 6V = I_2\,5\Omega \Rightarrow I_2 = \frac{6}{5}A$

(c) $\left(\frac{6}{5}A\right)5\Omega - I_5 4\Omega = 0 \Rightarrow \left(\frac{6}{\cancel{5}}A\right)\cancel{5}\Omega = I_5 4\Omega \Rightarrow I_5 = \frac{6}{4}A = \frac{3}{2}A$

$= 0.4A - 1.2A = -0.8A = I_4$

$= I_5 - I_3 = \frac{3}{2}A + 0.8A = 2.3A$

You can also use a hybrid technique that ignores nodes



note: current through 5Ω is $I_A - I_B$
4Ω is $I_B - I_c$ etc.

I was trained to do the drops around each loop

$10V - I_A 10\Omega - (I_A - I_B)5\Omega = 0$

$(I_A - I_B)5\Omega - (I_B - I_C)4\Omega = 0$

$6V + (I_B - I_c)4\Omega = 0 \Rightarrow (I_B - I_c) = +\frac{3}{2}A$ (I_5 from previous!)

$I_A - I_B)5\Omega - (\frac{3}{2}A)4\Omega = 0$

$(I_A - I_B) = \frac{6}{5}A$ (I_2 from previous!)

$10V - I_A 10\Omega - \frac{6}{5}A(5\Omega) = 0 \Rightarrow 4V - I_A 10\Omega = 0$, I_A
(I_1 from previous

$0.4A - I_B = 1.2A$ $\quad I_B = -0.8A$ (I_3, I_4 from before)

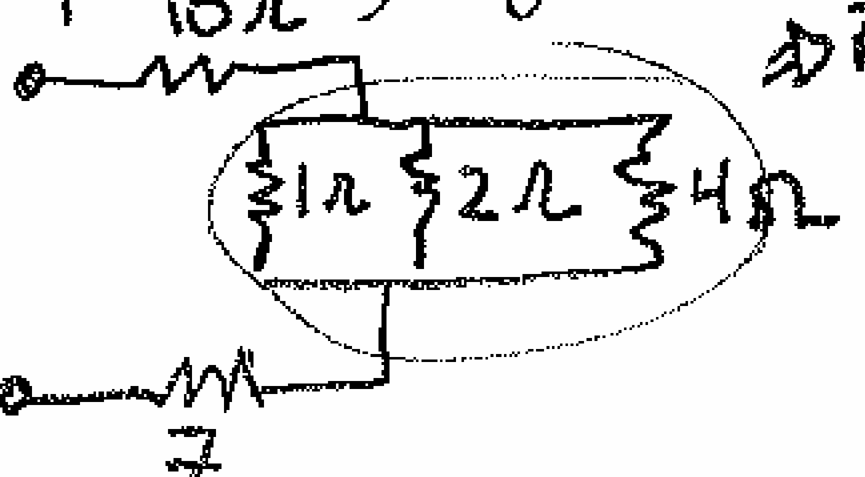
$-0.8A - I_c = 1.5A$ $\quad I_c = -0.8A - 1.5A = -2.3A$
($-I_6$ from before)

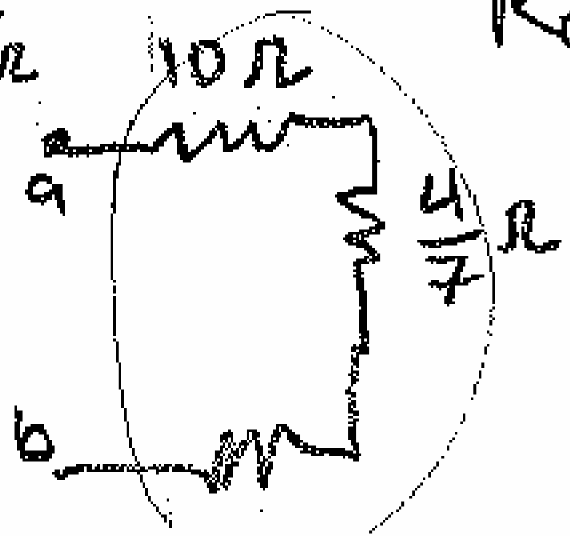
Both techniques are a valid way to approach the problem. Notice how we could have surmised from the start that 6V must be across both the 5Ω & 4Ω.

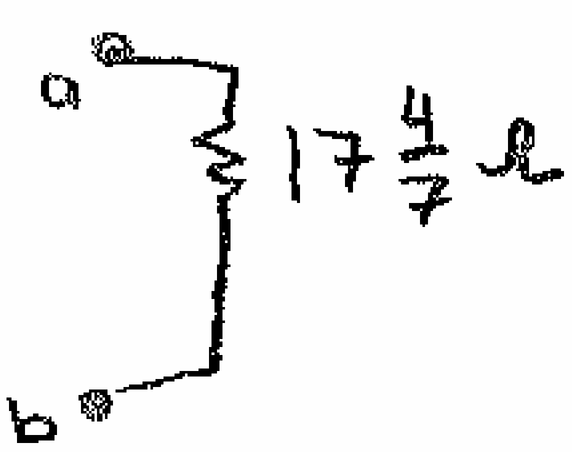
& Finding Equivalent Resistance as before

$\frac{1}{R_{eq}} = \frac{1}{1\Omega} + \frac{1}{2\Omega} + \frac{1}{4\Omega}$ $\Rightarrow R_{eq} = \frac{4}{7}\Omega$

$R_{eq} = 17\frac{4}{7}\Omega$

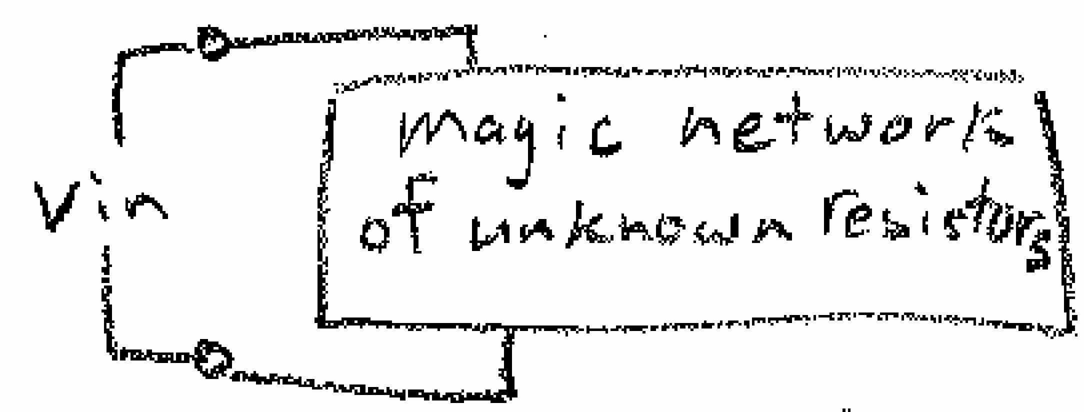






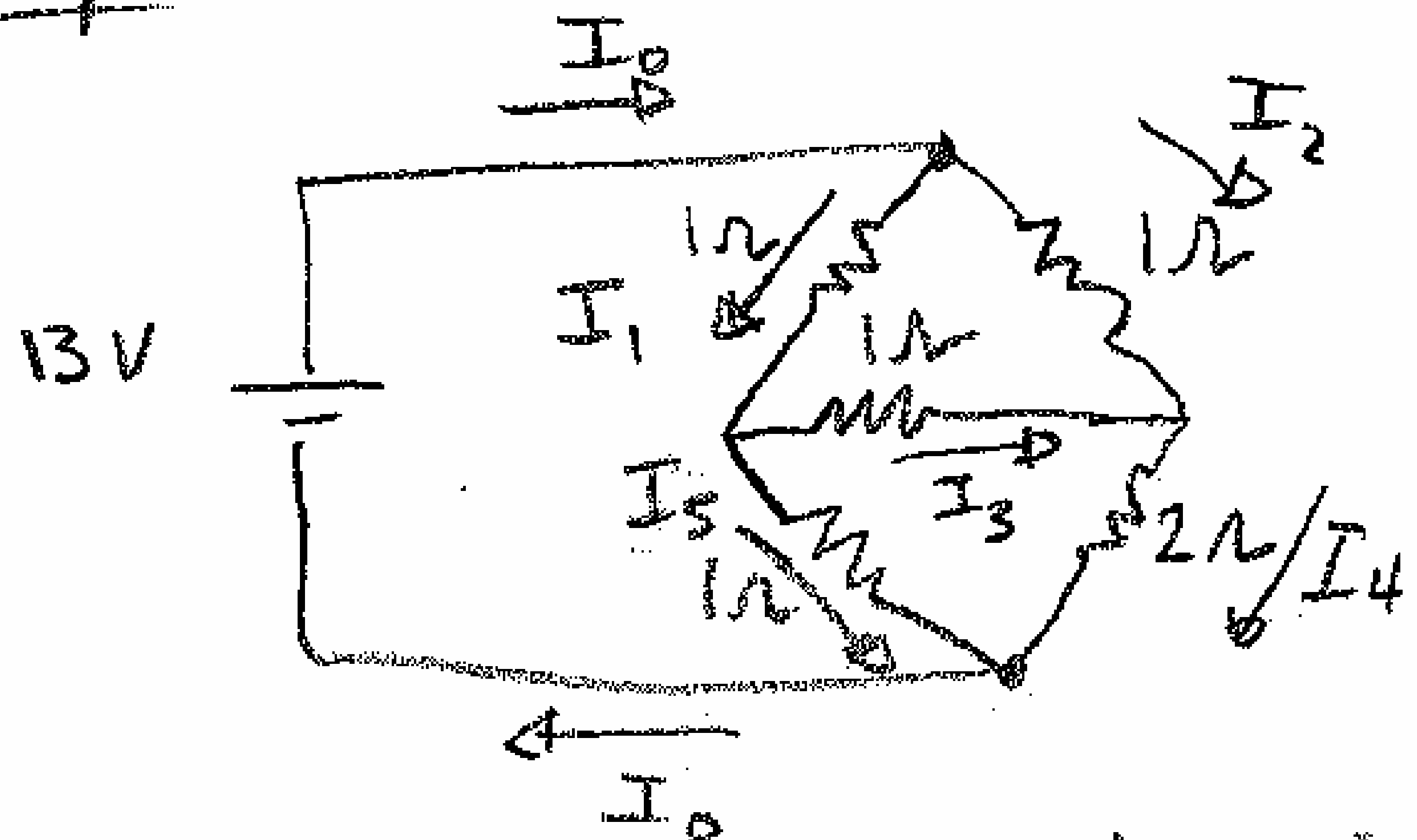
You can also define an equivalent Resistance

$\frac{V_{in}}{I_0}$ consider



& you'll see problems where the "divide & conquer" method fails. (purely resistive networks don't have the same "hidden charge issue"

Example in book



$R_{eq} = ?$

$I_0 = I_1 + I_2$

$I_1 = I_3 + I_5$

$I_2 = I_4 - I_3$

$I_5 + I_4 = I_0$

choose enough paths for each resistor

(a) $13V - I_1(1\Omega) - I_5(1\Omega) = 0 = 13V - I_1(1\Omega) - (I_1 - I_3)(1\Omega) = 0$

(b) $13V - I_2(1\Omega) - I_4(2\Omega) = 0 = 13V - I_2(1\Omega) - (I_2 + I_3)2\Omega = 0$

(c) $-I_1(1\Omega) - I_3(1\Omega) + I_2(1\Omega) = 0$

$13V - I_1(2\Omega) + I_3(1\Omega) = 0 \Rightarrow 13V + I_3(1\Omega) = I_1(2\Omega) \Rightarrow I_1 = 6.5A + \frac{1}{2} I_3$

$13V - I_2(3\Omega) - I_3(2\Omega) = 0 \Rightarrow I_2(3\Omega) = 13V - I_3(2\Omega) \Rightarrow I_2 = \frac{13}{3}A - \frac{2}{3} I_3$

$-(6.5A + \frac{1}{2} I_3)1\Omega - I_3(1\Omega) + (\overbrace{\frac{13}{3}A}^{4.333} - \frac{2}{3} I_3)1\Omega = 0 \Rightarrow -2.17A + 2.17 I_3 = 0$

$I_3 = -1A,\ I_1 = 6A,\ I_2 = \frac{15}{3}A = 5\Omega$ $\quad I_0 = 11A \quad R_{eq} = \frac{13V}{11A} = 1.18\Omega$

ote: If $I_3 = 0$

$I_1 = I_5 \quad I_1 R_1 = I_2 R_3$

$I_2 = I_4 \quad I_1 R_2 = I_2 R_4$

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ Bridge