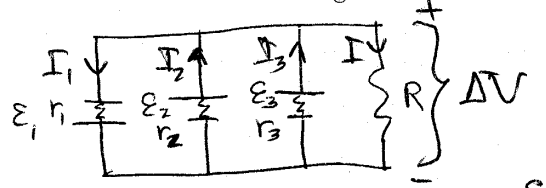
Yellow

6. (20 pts) For the circuit below, take $\mathcal{E}_1 = 12$ V, $\mathcal{E}_2 = 20$ V, $\mathcal{E}_3 = 16$ V, $r_1 = 0.02\ \Omega$, $r_2 = 0.01\ \Omega$, $r_3 = 0.02\ \Omega$, $R = 0.04\ \Omega$. (1) Indicate your definitions of the directions of positive currents and of the positive side of the voltage ΔV across R. (2) Analyze the circuit using Kirchhoff's rules. (3) Solve for the voltage across R. (4) Find the current through R and the currents provided by each of the batteries.



$$I_2 + I_3 = I + I_1$$

$$\frac{\mathcal{E}_2 - \Delta V}{r_2} + \frac{\mathcal{E}_3 - \Delta V}{r_3} = \frac{\Delta V}{R} + \frac{\mathcal{E}_1 + \Delta V}{r_1}$$

$$\frac{\mathcal{E}_2}{r_2} + \frac{\mathcal{E}_3}{r_3} - \frac{\mathcal{E}_1}{r_1} = \Delta V\left(\frac{1}{R} + \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right)$$

$$2000 + 800 - 600 = \Delta V(25 + 50 + 100 + 50)$$

$$\Delta V = \frac{2200}{225} = 9.78\ \text{V}$$

$$I = \frac{\Delta V}{R} = 244.4$$

$$I_1 = \frac{\mathcal{E}_1 + \Delta V}{r_1} = 1088.9$$

sums to 1333.3

$$I_2 = \frac{\mathcal{E}_2 - \Delta V}{r_2} = 1022.2$$

$$I_3 = \frac{\mathcal{E}_3 - \Delta V}{r_3} = 311.1$$

sums to 1333.3

7. (15 pts) You are given 60 identical voltaic cells with 1.2 V emf and and 0.25 ohm internal resistance. Determine the maximum current that can be provided when these are connected so that they constitute an 18 V battery. Determine the effective internal resistance of this battery.

$\frac{18\text{V}}{1.2} = 15$, so use 15 cells in series

Then use 4 sets of these in parallel.

The maximum current of one cell is $\frac{1.2}{0.25} = 4.8\ \text{A}$,

and this is the current of the 15 cells in series.

So together, with 4 sets of 15 in parallel, $I_{max} = 4(4.8) = 19.2\ \text{A}$.

With $\mathcal{E} = 18\text{V}$ and $I_{max} = \frac{\mathcal{E}}{r_{eff}}$, we have

$$r_{eff} = \frac{\mathcal{E}}{I_{max}} = 0.9375\ \Omega.$$

Or: 15 of (0.25Ω) in series is 3.75Ω.
and 4 of (3.75Ω) in parallel is 0.9375.