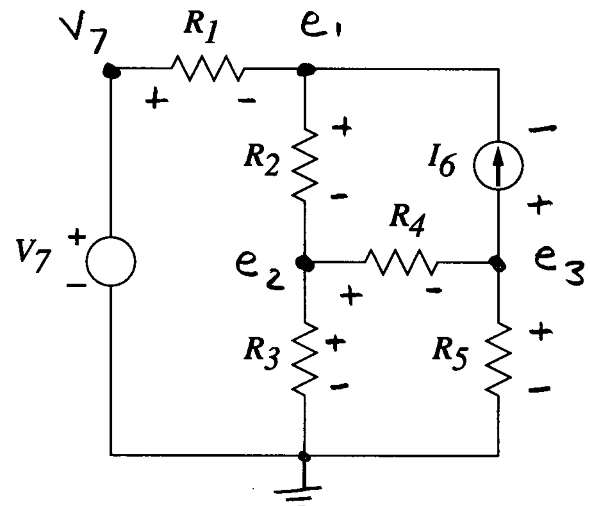
1. The first steps are to label the node potentials (to allow solution by the node method) and to label each element with +/− signs (so we can talk about branch currents, voltages).




Next, we write KCL at each node with unknown potential. This can be done "by inspection," as in class:

$$e_1: \quad \left(\frac{1}{R_1} + \frac{1}{R_2}\right) e_1 - \frac{1}{R_2} e_2 = \frac{1}{R_1} V_7 + I_6$$

$$e_2: \quad -\frac{1}{R_2} e_1 + \left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right) e_2 - \frac{1}{R_4} e_3 = 0$$

$$e_3: \quad -\frac{1}{R_4} e_2 + \left(\frac{1}{R_4} + \frac{1}{R_5}\right) e_3 = -I_6$$

Plugging in values, we have that:

$$\frac{5}{6}e_1 - \frac{1}{2}e_2 = 6$$

$$-\frac{1}{2}e_1 + \frac{7}{6}e_2 - \frac{1}{3}e_3 = 0$$

$$-\frac{1}{3}e_2 + \frac{4}{3}e_3 = -5$$

(I've dropped units here.) We can solve by Cramer's rule, Gaussian elimination, calculator, etc. The result is

$$e_1 = 9\text{ V}$$
$$e_2 = 3\text{ V}$$
$$e_3 = -3\text{ V}$$

The branch voltages are just the difference in node potentials across each element:

$$v_1 = -6\text{ V}$$
$$v_2 = 6\text{ V}$$
$$v_3 = 3\text{ V}$$
$$v_4 = 6\text{ V}$$
$$v_5 = -3\text{ V}$$
$$v_6 = -12\text{ V}$$
$$v_7 = 3\text{ V}$$

The branch currents are found by applying the constitutive laws:

$$
\begin{aligned}
i_1 &= v_1/R_1 = -2\text{ A} \\
i_2 &= v_2/R_2 = 3\text{ A} \\
i_3 &= v_3/R_3 = 1\text{ A} \\
i_4 &= v_4/R_4 = 2\text{ A} \\
i_5 &= v_5/R_5 = -3\text{ A} \\
i_6 &= I_6 = 5\text{ A}
\end{aligned}
$$

Note that the constitutive law for the voltage source,

$$v_7 = V_7, \quad \text{for all } i_7$$

gives no information about $i_7$. To find $i_7$, apply KCL at the $V_7$ node:

$$i_7 + i_1 = 0$$

$$\Rightarrow \boxed{i_7 = +2A}$$

2. Find the net power dissipated by the circuit:

$$
\begin{aligned}
P &= \sum_n i_n v_n \\
&= (-2)(-6) + (3)(6) + (1)(3) + (2)(6) + (-3)(-3) \\
&\quad + (5)(-12) + (2)(3)
\end{aligned}
$$

$$\Rightarrow \mathbb{P} = 12 + 18 + 3 + 12 + 9 - 60 + 6 = 0\,W$$

$$\boxed{\mathbb{P} = 0\ W}$$

Note that the current source <u>supplies</u> power (−60 W), and the voltage source <u>absorbs</u> power (+6 W).