ENSC 220 – Assignment #1 Solutions

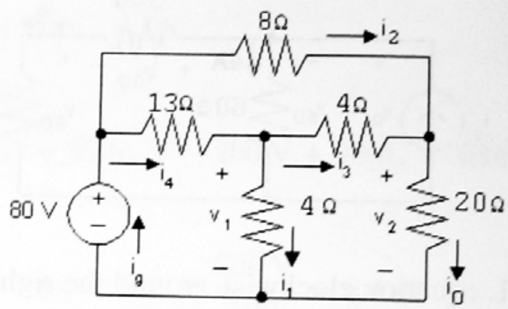
P 2.15 **[a]**

$$v_o = 8i_a + 14i_a + 18i_a = 40(20) = 800 \text{ V}$$
$$800 = 10i_o$$
$$i_o = 800/10 = 80 \text{ A}$$

[b] $i_g = i_a + i_o = 20 + 80 = 100$ A

[c] $p_g(\text{delivered}) = (100)(800) = 80{,}000 \text{ W} = 80 \text{ kW}$

P 2.17 **[a]**



$$v_2 = 2(20) = 40 \text{ V}$$
$$v_{8\Omega} = 80 - 40 = 40 \text{ V}$$
$$i_2 = 40 \text{ V}/8\,\Omega = 5 \text{ A}$$
$$i_3 = i_o - i_2 = 2 - 5 = -3 \text{ A}$$
$$v_{4\Omega} = (-3)(4) = -12 \text{ V}$$
$$v_1 = 4i_3 + v_2 = -12 + 40 = 28 \text{ V}$$
$$i_1 = 28 \text{ V}/4\,\Omega = 7 \text{ A}$$

[b] $i_4 = i_1 + i_3 = 7 - 3 = 4$ A

$$p_{13\Omega} = 4^2(13) = 208 \text{ W}$$
$$p_{8\Omega} = (5)^2(8) = 200 \text{ W}$$
$$p_{4\Omega} = 7^2(4) = 196 \text{ W}$$
$$p_{4\Omega} = (-3)^2(4) = 36 \text{ W}$$
$$p_{20\Omega} = 2^2(20) = 80 \text{ W}$$

[c] $\sum P_{\text{dis}} = 208 + 200 + 196 + 36 + 80 = 720 \text{ W}$

$$i_g = i_4 + i_2 = 4 + 5 = 9 \text{ A}$$
$$P_{\text{dev}} = (9)(80) = 720 \text{ W}$$

P 3.8 **[a]** $5\|20 = 100/25 = 4\,\Omega$

$9\|18 = 162/27 = 6\,\Omega$

$R_{\text{ab}} = 5 + 12 + 3 = 20\,\Omega$

$5\|20 + 9\|18 + 10 = 20\,\Omega$

$20\|30 = 600/50 = 12\,\Omega$

[b] $5 + 15 = 20\,\Omega$

$20\|60 = 1200/80 = 15\,\Omega$

$15 + 10 = 25\,\Omega$

$25\|75 = 1875/100 = 18.75\,\Omega$

$18.75 + 11.25 = 30\,\Omega$

$30\|20 = 600/50 = 12\,\Omega$

$3\|6 = 18/9 = 2\,\Omega$

$3\|6 + 30\|20 = 2 + 12 = 14\,\Omega$

$26\|14 = 364/40 = 9.1\,\Omega$

$R_{\text{ab}} = 2.5 + 9.1 + 3.4 = 15\,\Omega$

[c] $3 + 5 = 8\,\Omega$

$8\|12 = 96/20 = 4.8\,\Omega$

$4.8 + 5.2 = 10\,\Omega$

$45 + 15 = 60\,\Omega$

$60\|40 = 2400/100 = 24\,\Omega$

$24 + 6 = 30\,\Omega$

$30\|10 = 300/40 = 7.5\,\Omega$

$R_{\text{ab}} = 1.5 + 7.5 + 1.0 = 10\,\Omega$

P 3.13 **[a]** We can calculate the no-load voltage using voltage division to determine the voltage drop across the 500 Ω resistor:

$$v_o = \frac{500}{(2000 + 500)}(50\ \text{V}) = 10\ \text{V}$$

[b] We can calculate the power if we know the current in each of the resistors. Under no-load conditions, the resistors are in series, so we can use Ohm's law to calculate the current they share:

$$i = \frac{50\ \text{V}}{2000\ \Omega + 500\ \Omega} = 0.02\ \text{A} = 20\ \text{mA}$$

Now use the formula $p = Ri^2$ to calculate the power dissipated by each resistor:

$$P_{R_1} = (2000)(0.02)^2 = 0.8\ \text{W} = 800\ \text{mW}$$

$$P_{R_2} = (500)(0.02)^2 = 0.2\ \text{W} = 200\ \text{mW}$$

[c] Since R_1 and R_2 carry the same current and $R_1 > R_2$ to satisfy the no-load voltage requirement, first pick R_1 to meet the 1 W specification

$$i_{R_1} = \frac{50 - 15}{R_1}, \quad \text{Therefore,} \left(\frac{35}{R_1}\right)^2 R_1 \leq 1$$

$$\text{Thus, } R_1 \geq \frac{35^2}{1} \quad \text{or} \quad R_1 \geq 1225\ \Omega$$

Now use the voltage specification:

$$\frac{R_2}{R_2 + 1225}(50) = 10$$

Thus, $R_2 = 306.25\ \Omega$

$R_1 = 1225\ \Omega$ and $R_2 = 306.25\ \Omega$ are the smallest values of resistors that satisfy the 1 W specification.

P 3.21 Begin by using the relationships among the branch currents to express all branch currents in terms of i_4:

$$i_1 = 2i_2 = 2(10i_3) = 20i_4$$

$$i_2 = 10i_3 = 10i_4$$

$$i_3 = i_4$$

Now use KCL at the top node to relate the branch currents to the current supplied by the source.

$$i_1 + i_2 + i_3 + i_4 = 8 \text{ mA}$$

Express the branch currents in terms of i_4 and solve for i_4:

$$8 \text{ mA} = 20i_4 + 10i_4 + i_4 + i_4 = 32i_4 \qquad \text{so} \qquad i_4 = \frac{0.008}{32} = 0.00025 = 0.25 \text{ mA}$$

Since the resistors are in parallel, the same voltage, 4 V appears across each of them. We know the current and the voltage for R_4 so we can use Ohm's law to calculate R_4:

$$R_4 = \frac{v_g}{i_4} = \frac{4 \text{ V}}{0.25 \text{ mA}} = 16 \text{ k}\Omega$$

Calculate i_3 from i_4 and use Ohm's law as above to find R_3:

$$i_3 = i_4 = 0.25 \text{ mA} \qquad \therefore \quad R_3 = \frac{v_g}{i_3} = \frac{4 \text{ V}}{0.25 \text{ mA}} = 16 \text{ k}\Omega$$

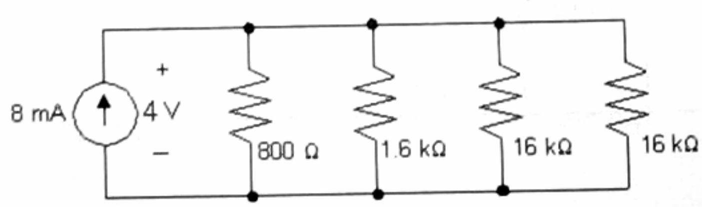
Calculate i_2 from i_4 and use Ohm's law as above to find R_2:

$$i_2 = 10i_4 = 10(0.25 \text{ mA}) = 2.5 \text{ mA} \qquad \therefore \quad R_2 = \frac{v_g}{i_2} = \frac{4 \text{ V}}{2.5 \text{ mA}} = 1.6 \text{ k}\Omega$$

Calculate i_1 from i_4 and use Ohm's law as above to find R_1:

$$i_1 = 20i_4 = 20(0.25 \text{ mA}) = 5 \text{ mA} \qquad \therefore \quad R_1 = \frac{v_g}{i_1} = \frac{4 \text{ V}}{5 \text{ mA}} = 800 \,\Omega$$

The resulting circuit is shown below:



P 3.29 **[a]** $v_{9\Omega} = (1)(9) = 9$ V

$i_{2\Omega} = 9/(2+1) = 3$ A

$i_{4\Omega} = 1 + 3 = 4$ A;

$v_{25\Omega} = (4)(4) + 9 = 25$ V

$i_{25\Omega} = 25/25 = 1$ A;

$i_{3\Omega} = i_{25\Omega} + i_{9\Omega} + i_{2\Omega} = 1 + 1 + 3 = 5$ A;

$v_{40\Omega} = v_{25\Omega} + v_{3\Omega} = 25 + (5)(3) = 40$ V

$i_{40\Omega} = 40/40 = 1$ A

$i_{5\|20\Omega} = i_{40\Omega} + i_{25\Omega} + i_{4\Omega} = 1 + 1 + 4 = 6$ A

$v_{5\|20\Omega} = (4)(6) = 24$ V

$v_{32\Omega} = v_{40\Omega} + v_{5\|20\Omega} = 40 + 24 = 64$ V

$i_{32\Omega} = 64/32 = 2$ A;

$i_{10\Omega} = i_{32\Omega} + i_{5\|20\Omega} = 2 + 6 = 8$ A

$v_g = 10(8) + v_{32\Omega} = 80 + 64 = 144$ V.

[b] $P_{20\Omega} = \dfrac{(v_{5\|20\Omega})^2}{20} = \dfrac{24^2}{20} = 28.8$ W