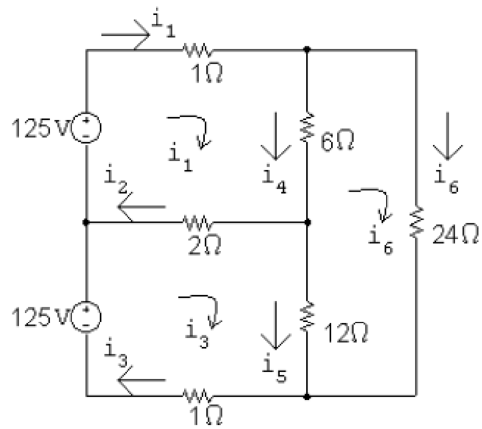
Problem #4 Solution

P 4.31 [a]



The three mesh current equations are:

$$-125 + 1i_1 + 6(i_1 - i_6) + 2(i_1 - i_3) = 0$$

$$24i_6 + 12(i_6 - i_3) + 6(i_6 - i_1) = 0$$

$$-125 + 2(i_3 - i_1) + 12(i_3 - i_6) + 1i_3 = 0$$

Place these equations in standard form:

$$i_1(1 + 6 + 2) + i_3(-2) + i_6(-6) = 125$$

$$i_1(-6) + i_3(-12) + i_6(24 + 12 + 6) = 0$$

$$i_1(-2) + i_3(2 + 12 + 1) + i_6(-12) = 125$$

Solving, $i_1 = 23.76$ A; $i_3 = 18.43$ A; $i_6 = 8.66$ A

Now calculate the remaining branch currents:

$$i_2 = i_1 - i_3 = 5.33 \text{ A}$$

$$i_4 = i_1 - i_6 = 15.10 \text{ A}$$

$$i_5 = i_3 - i_6 = 9.77 \text{ A}$$

[b] $p_{\rm sources} = p_{\rm top} + p_{\rm bottom} = -(125)(23.76) - (125)(18.43)$

$$= -2970 - 2304 = -5274 \text{ W}$$

Thus, the power developed in the circuit is 5274 W.
Now calculate the power absorbed by the resistors:

$$p_{\rm 1top} = (23.76)^2(1) = 564.54 \text{ W}$$

$$p_2 = (5.33)^2(2) = 56.82 \text{ W}$$

$$p_{\rm 1bot} = (18.43)^2(1) = 339.66 \text{ W}$$

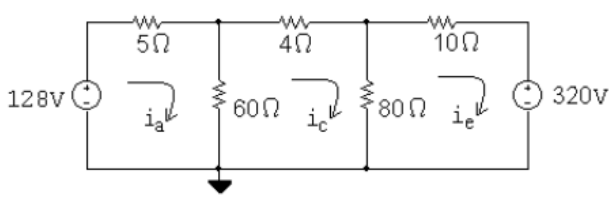
$$p_6 = (15.10)^2(6) = 1368.06 \text{ W}$$

$$p_{12} = (9.77)^2(12) = 1145.43 \text{ W}$$

$$p_{24} = (8.66)^2(24) = 1799.89 \text{ W}$$

The power absorbed by the resistors is
$564.54 + 56.82 + 339.66 + 1368.06 + 1145.43 + 1799.89 = 5274$ W so the power balances.

P 4.32 [a]



The three mesh current equations are:

$$-128 + 5i_{\rm a} + 60(i_{\rm a} - i_{\rm c}) = 0$$

$$4i_{\rm c} + 80(i_{\rm c} - i_{\rm e}) + 60(i_{\rm c} - i_{\rm a}) = 0$$

$$320 + 80(i_{\rm e} - i_{\rm c}) + 10i_{\rm e} = 0$$

Place these equations in standard form:

$$i_{\rm a}(5 + 60) + i_{\rm c}(-60) + i_{\rm e}(0) = 128$$

$$i_{\rm a}(-60) + i_{\rm c}(4 + 80 + 60) + i_{\rm e}(-80) = 0$$

$$i_{\rm a}(0) + i_{\rm c}(-80) + i_{\rm e}(80 + 10) = -320$$

Solving, $i_{\rm a} = -6.8$ A; $\quad i_{\rm c} = -9.5$ A; $\quad i_{\rm e} = -12$ A

Now calculate the remaining branch currents:

$$i_b = i_a - i_c = 2.7 \text{ A}$$

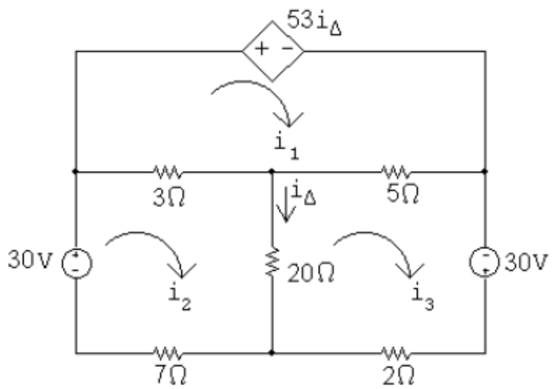
$$i_d = i_c - i_e = 2.5 \text{ A}$$

[b] $p_{128V} = -(128)i_a = -(128)(-6.8) = 870.4$ W (abs)

$p_{320V} = (320)i_e = (320)(-12) = -3840$ W (dev)

Thus, the power developed in the circuit is 3840 W. Note that the resistors cannot develop power!

P 4.40



Mesh equations:

$$53i_\Delta + 8i_1 - 3i_2 - 5i_3 = 0$$

$$0i_\Delta - 3i_1 + 30i_2 - 20i_3 = 30$$

$$0i_\Delta - 5i_1 - 20i_2 + 27i_3 = 30$$

Constraint equations:

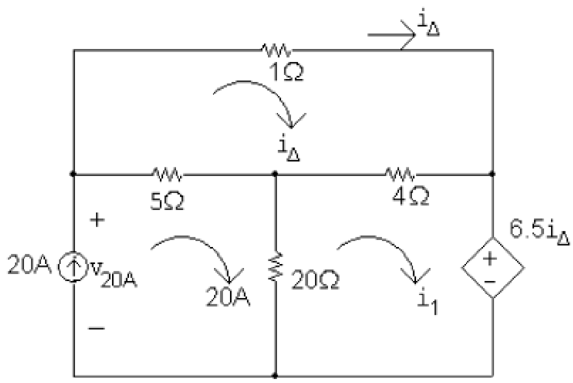
$$i_\Delta = i_2 - i_3$$

Solving, $i_1 = 110$ A; $i_2 = 52$ A; $i_3 = 60$ A; $i_\Delta = -8$ A

$$p_{\text{depsource}} = 53i_\Delta i_1 = (53)(-8)(110) = -46{,}640 \text{ W}$$

Therefore, the dependent source is developing 46,640 W.

P 4.45



Mesh equations:

$$10i_\Delta - 4i_1 = 100$$

$$-4i_\Delta + 24i_1 + 6.5i_\Delta = 400$$

Solving, $i_1 = 15$ A; $\quad i_\Delta = 16$ A

$$v_{20\text{A}} = 1i_\Delta + 6.5i_\Delta = 7.5(16) = 120 \text{ V}$$

$$p_{20\text{A}} = -20v_{20\text{A}} = -(20)(120) = -2400 \text{ W (del)}$$

$$p_{6.5i_\Delta} = 6.5i_\Delta i_1 = (6.5)(16)(15) = 1560 \text{ W (abs)}$$

Therefore, the independent source is developing 2400 W, all other elements are absorbing power, and the total power developed is thus 2400 W.
CHECK:

$$p_{1\Omega} = (16)^2(1) = 256 \text{ W}$$

$$p_{5\Omega} = (20 - 16)^2(5) = 80 \text{ W}$$

$$p_{4\Omega} = (1)^2(4) = 4 \text{ W}$$

$$p_{20\Omega} = (20 - 15)^2(20) = 500 \text{ W}$$

$$\sum p_{\text{abs}} = 1560 + 256 + 80 + 4 + 500 = 2400 \text{ W (CHECKS)}$$