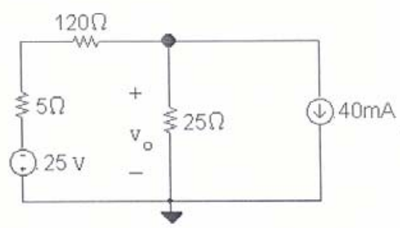
Homework 3
Solution

P 4.6



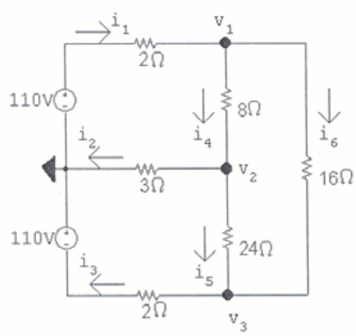
Note that we have chosen the lower node as the reference node, and that the voltage at the upper node with respect to the reference node is v_o. Write a KCL equation (node voltage equation)by summing the currents leaving the upper node:

$$\frac{v_o + 25}{120 + 5} + \frac{v_o}{25} + 0.04 = 0$$

Solve by multiplying both sides of the KCL equation by 125 and collecting the terms involving v_o on one side of the equation and the constants on the other side of the equation:

$v_o + 25 + 5v_o + 5 = 0 \qquad \therefore \qquad 6v_o = -30 \qquad$ so $\qquad v_o = -30/6 = -5$ V

P 4.11 **[a]**



$$\frac{v_1 - 110}{2} + \frac{v_1 - v_2}{8} + \frac{v_1 - v_3}{16} = 0 \qquad \text{so} \qquad 11v_1 - 2v_2 - v_3 = 880$$

$$\frac{v_2 - v_1}{8} + \frac{v_2}{3} + \frac{v_2 - v_3}{24} = 0 \qquad \text{so} \qquad -3v_1 + 12v_2 - v_3 = 0$$

$$\frac{v_3 + 110}{2} + \frac{v_3 - v_2}{24} + \frac{v_3 - v_1}{16} = 0 \qquad \text{so} \qquad -3v_1 - 2v_2 + 29v_3 = -2640$$

Solving, $v_1 = 74.64$ V; $\quad v_2 = 11.79$ V; $\quad v_3 = -82.5$ V

Thus, $i_1 = \frac{110 - v_1}{2} = 17.68$ A $\qquad i_4 = \frac{v_1 - v_2}{8} = 7.86$ A

$i_2 = \frac{v_2}{3} = 3.93$ A $\qquad i_5 = \frac{v_2 - v_3}{24} = 3.93$ A

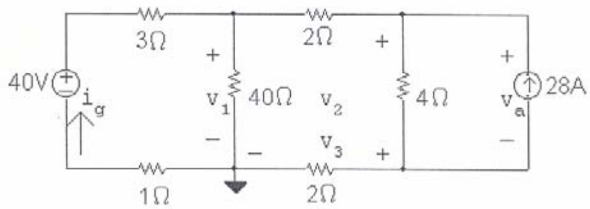
$i_3 = \frac{v_3 + 110}{2} = 13.75$ A $\qquad i_6 = \frac{v_1 - v_3}{16} = 9.82$ A

[b] $\sum P_{\text{dev}} = 110i_1 + 110i_3 = 3457.14$ W

$\sum P_{\text{dis}} = i_1^2(2) + i_2^2(3) + i_3^2(2) + i_4^2(8) + i_5^2(24) + i_6^2(16) = 3457.14$ W

P 4.12

P 4.14



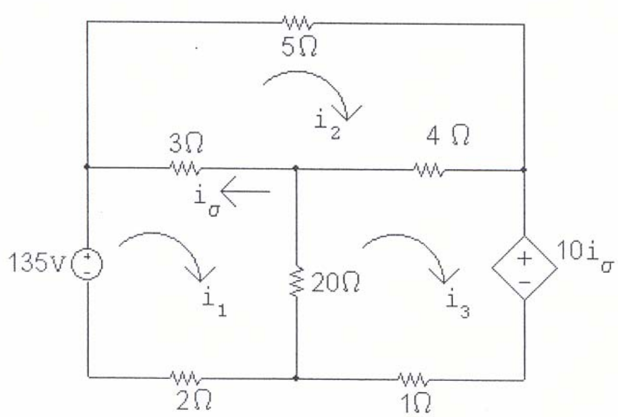
The three node voltage equations are:

$$
\begin{aligned}
\frac{v_1 - 40}{4} + \frac{v_1}{40} + \frac{v_1 - v_2}{2} &= 0 \\
\frac{v_2 - v_1}{2} + \frac{v_2 - v_3}{4} - 28 &= 0 \\
\frac{v_3}{2} + \frac{v_3 - v_2}{4} + 28 &= 0
\end{aligned}
$$

Place these equations in standard form:

$$
\begin{aligned}
v_1\left(\frac{1}{4} + \frac{1}{40} + \frac{1}{2}\right) \quad &+ \quad v_2\left(-\frac{1}{2}\right) \quad &+ \quad v_3(0) \quad &= \quad \frac{40}{4} \\
v_1\left(-\frac{1}{2}\right) \quad &+ \quad v_2\left(\frac{1}{2} + \frac{1}{4}\right) \quad &+ \quad v_3\left(-\frac{1}{4}\right) \quad &= \quad 28 \\
v_1(0) \quad &+ \quad v_2\left(-\frac{1}{4}\right) \quad &+ \quad v_3\left(\frac{1}{2} + \frac{1}{4}\right) \quad &= \quad -28
\end{aligned}
$$

P 4.33



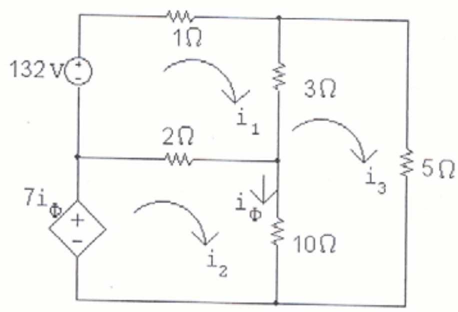
$$
\begin{aligned}
-135 + 3(i_1 - i_2) + 20(i_1 - i_3) + 2i_1 &= 0 \\
5i_2 + 4(i_2 - i_3) + 3(i_2 - i_1) &= 0 \\
10i_\sigma + 1i_3 + 20(i_3 - i_1) + 4(i_3 - i_2) &= 0
\end{aligned}
$$

The dependent source constraint equation is:
$i_\sigma = i_2 - i_1$
Place these equations in standard form:

$$
\begin{aligned}
i_1(3 + 20 + 2) + i_2(-3) + i_3(-20) + i_\sigma(0) &= 135 \\
i_1(-3) + i_2(5 + 4 + 3) + i_3(-4) + i_\sigma(0) &= 0 \\
i_1(-20) + i_2(-4) + i_3(1 + 20 + 4) + i_\sigma(10) &= 0 \\
i_1(1) + i_2(-1) + i_3(0) + i_\sigma(1) &= 0
\end{aligned}
$$

Solving, $i_1 = 64.8$ A, $i_2 = 39$ A; $i_3 = 68.4$ A; $i_\sigma = -25.8$ A
Calculate the power:
$p_{20\Omega} = 20(68.4 - 64.8)^2 = 259.2$ W
Thus the 20 Ω resistor dissipates 259.2 W.

P 4.34



The mesh current equations:

$$
\begin{aligned}
-132 + 1i_1 + 3(i_1 - i_3) + 2(i_1 - i_2) &= 0 \\
-7i_\phi + 2(i_2 - i_1) + 10(i_2 - i_3) &= 0 \\
5i_3 + 10(i_3 - i_2) + 3(i_3 - i_1) &= 0
\end{aligned}
$$

The dependent source constraint equation:
$i_\phi = i_2 - i_3$

Place these equations in standard form:

$$
\begin{aligned}
i_1(1 + 3 + 2) + i_2(-2) + i_3(-3) + i_\phi(0) &= 132 \\
i_1(-2) + i_2(10 + 2) + i_3(-10) + i_\phi(-7) &= 0 \\
i_1(-3) + i_2(-10) + i_3(5 + 10 + 3) + i_\phi(0) &= 0 \\
i_1(0) + i_2(-1) + i_3(1) + i_\phi(1) &= 0
\end{aligned}
$$

Solving, $i_1 = 48$ A; $i_2 = 36$ A; $i_3 = 28$ A; $i_\phi = 8$ A

Solve for the power:

$p_{\text{dep source}} = -7(i_\phi)i_2 = -7(8)(36) = -2016$ W

Thus, the dependent source is developing 2016 W.