

3.12

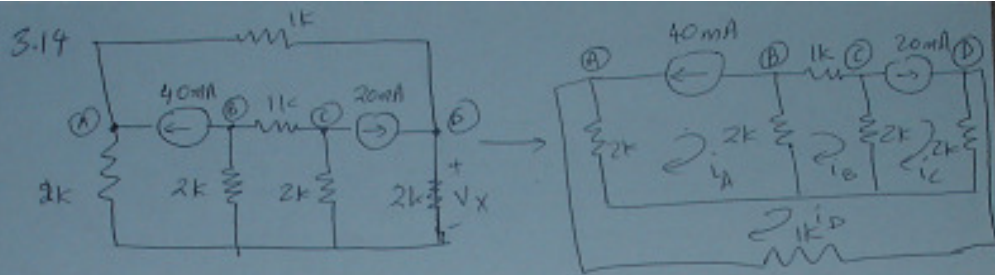
The KVL loop encircles the entire circuit, and the KVL current is denoted i ; its direction is counter-clockwise. We have

$$(R_1 + R_2 + R_3 + R_4 + R_5)i = -v_s + i_s(R_3 + R_4 + R_5).$$

As a result, $i = 25$ mA, which is the current passing through R_1 and R_2 ; hence, $i_x = 25$ mA. It follows that $v_x = -(i - i_s)R_4 = 18.75$ V. The power dissipated is given by

$$i^2(R_1 + R_2) + iv_s + (i_s - i)^2(R_3 + R_4 + R_5) = 3.75 \text{ W}.$$

Note that the voltage source is absorbing power, so we add it in considering the power dissipated.



$$i_A = -40 \text{ mA}$$

$$i_C = 20 \text{ mA}$$

$$V_x = 2k(i_C - i_D)$$

$$\text{loop B: } 1k i_B + 2k(i_B - i_C) + 2k(i_B - i_A) = 0$$

$$5k i_B - 2k i_C - 2k i_A = 0$$

$$5k i_B - 2k(20 \text{ mA}) = 2k(-40 \text{ mA})$$

$$5k i_B - 40 + 80 = 0$$

$$5k i_B = -40$$

$$i_B = -8 \text{ mA}$$

$$\text{loop D: } 2k(i_D - i_A) + 2k(i_D - i_C) + 1k i_D = 0$$

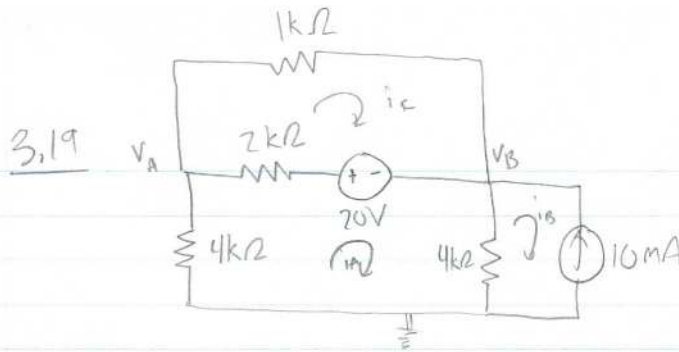
$$5k i_D - 2k i_A - 2k i_C = 0$$

$$5k i_D + 80 - 40 = 0$$

$$i_D = -8 \text{ mA}$$

$$V_x = 2k(20 + 8)$$

$$V_x = 2k(28) = 56 \text{ V}$$



$$i_A: -20 - 4k(i_A + 10mA) - 4k i_A - 2k(i_A - i_C) = 0$$

$$i_B: i_B = -10mA$$

$$-1k(i_C) + 20V - 2k(i_C - i_A) = 0$$

-10000	2000	60
10000	-3000	-20

$$\begin{aligned} i_A &= -5.385mA \\ i_C &= 3.077mA \end{aligned}$$

$$20 - 2(3.077 + 5.385) - 4(5.385) - 4(5.385 - 10) = 0 \quad \checkmark$$

$$\frac{V_B - 0}{4k} = 10 - 5.385 \Rightarrow V_B = 18.46V$$

$$\frac{V_A - V_B}{1k} = 3.077 \Rightarrow V_A = 21.54V$$

3.20

The mesh equations are given by the following matrix equation:

$$\begin{bmatrix} 14k & -10k & 0 & 0 \\ -10k & 13k & -2k & 0 \\ 0 & -2k & 16k & -6k \\ 0 & 0 & -6k & 6k \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \\ i_D \end{bmatrix} = \begin{bmatrix} -10V \\ 0 \\ 0 \\ 15V \end{bmatrix}.$$

Solving this equation, we have $i_A = -1.26$ mA, $i_B = -.76$ mA, $i_C = 1.35$ mA, and $i_D = 3.85$ mA.

Define the top middle and right middle nodes as node a and node b respectively. The matrix describing the nodal voltages is

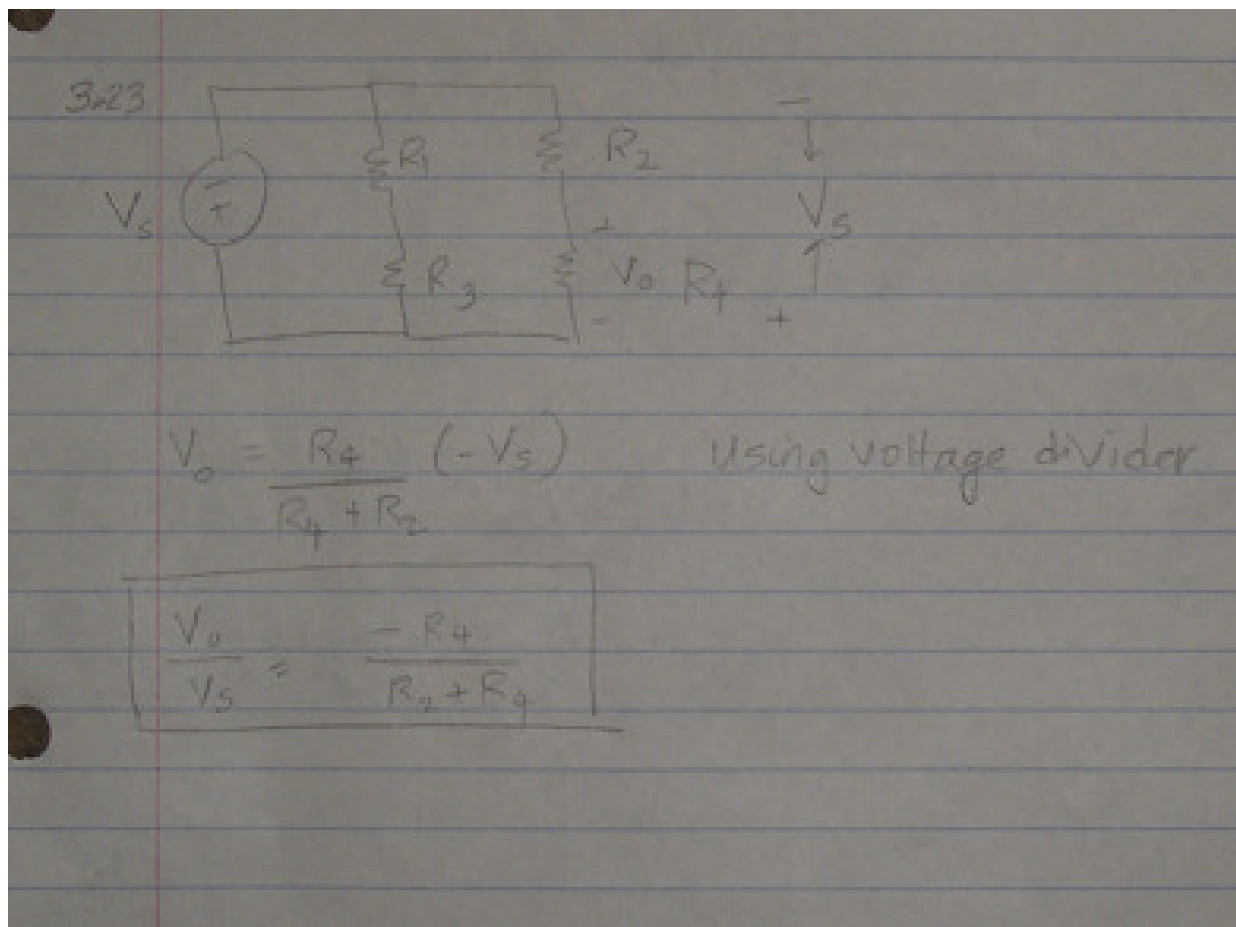
$$\begin{bmatrix} \frac{1}{4k} + \frac{1}{10k} + \frac{1}{1k} & -\frac{1}{1k} \\ -\frac{1}{1k} & \frac{1}{1k} + \frac{1}{2k} + \frac{1}{8k} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \end{bmatrix} = \begin{bmatrix} \frac{5}{4k} + \frac{15}{10k} \\ \frac{15}{2k} \end{bmatrix}.$$

We have that $v_A = 10.03$ V and $v_B = 10.79$ V. It is then possible to verify the mesh currents through repeated application of Ohm's law, e.g.

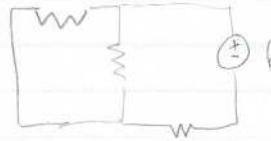
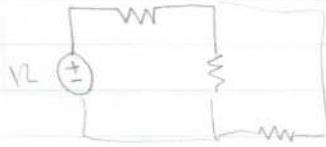
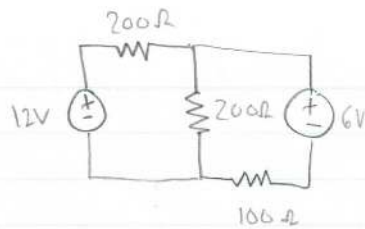
$$i_A = \frac{5 - v_a}{4k} = -1.26 \text{ mA},$$

$$i_B = \frac{v_A - v_B}{1k} = -.76 \text{ mA},$$

and so forth.



3.26



$$V_x = 12 \left(\frac{200 \parallel 100}{200 \parallel 100 + 200} \right)$$

$$V_x = 6 \left(\frac{200 \parallel 200}{200 \parallel 200 + 100} \right) = 3V$$

$$V_x = 3V$$

$$V_x = 3 + 3 = 6V$$

Check:

$$12V - i_A(200) - (i_A + i_B) 200 = 0$$

$$6V - (i_A + i_B) 100 - 100 i_B = 0$$

$$\begin{array}{cc|c} 400 & -200 & 12 \\ 200 & 300 & 6 \end{array} \quad \begin{array}{l} i_A = .03 \\ i_B = 0 \end{array}$$

$$V_x = 6V$$

3.32

Consider, for instance, two ideal voltage sources in series with one another and with the load resistance. We have, for the first voltage source,

$$P = .25 \text{ W} = \frac{v_{s1}^2}{100} \Rightarrow v_{s1} = 5 \text{ V},$$

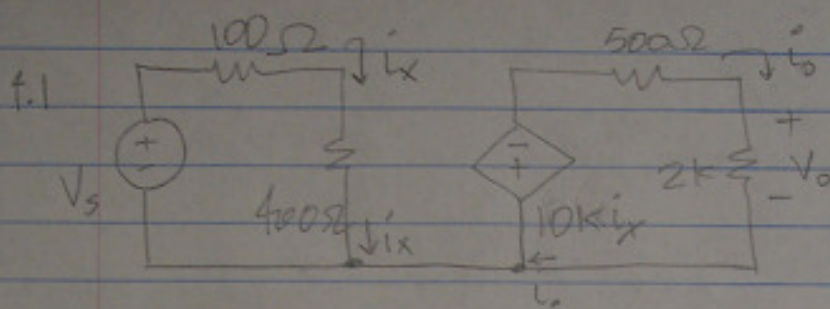
and for the second,

$$P = 4 \text{ W} = \frac{v_{s2}^2}{100} \Rightarrow v_{s2} = 20 \text{ V}.$$

The total power is

$$\frac{(v_{s1} + v_{s2})^2}{100} = 6.25 \text{ W}.$$

Clearly, since power is not linearly related to the i-v characteristics of a circuit, and superposition applies to the i-v characteristics because they are linearly related to one another, superposition does not apply to power computations.



$$i_x = \frac{V_s}{500}$$

$$i_o = \frac{-10k i_x}{2.5k} \quad (1)$$

Using voltage division

$$V_o = \frac{2k}{2.5k} (-10k i_x)$$

$$V_o = \frac{-2k (10k) (V_s)}{2.5k \cdot 5k} \quad (2)$$

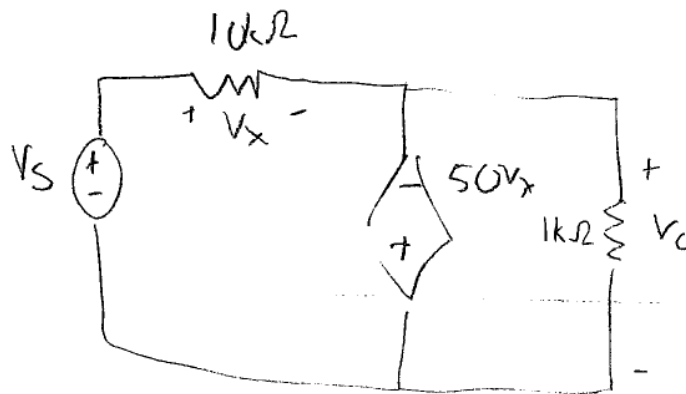
from (i)

$$\frac{V_o}{V_s} = \frac{-20}{1.25} = -16$$

from (ii)

$$\frac{i_o}{i_x} = \frac{-10k}{2.5k} = -4$$

4,5



$$V_S - V_x - V_o = 0 \quad -50V_x = V_o$$

$$V_S - \left(-\frac{V_o}{50}\right) - V_o = 0$$

$$V_S = \frac{50V_o}{50} - \frac{V_o}{50} = \frac{49V_o}{50}$$

$$\cancel{\frac{V_S}{V_o} = \frac{49}{50}} \quad \frac{V_o}{V_S} = \frac{50}{49}$$

4.11

Note that the answer in the book is incorrect. The equivalent resistance listed in the back of the book is R_P , which is an undefined variable.

Consider an arbitrary load resistance connected between the terminals. The voltage drop across the terminals is ri_s , where i_s is given by

$$\begin{aligned}i_s &= \frac{v_s - ri_s}{R_s} \\i_s(r + R_s) &= v_s \\i_s &= \frac{v_s}{r + R_s}.\end{aligned}$$

Note that this expression holds no matter the load resistance; hence, the only possible choice for R_{eq} is $R_{eq} = 0$ and v_{Th} is given by

$$v_{Th} = ri_s = \frac{rv_s}{r + R_s}.$$