2.3 A thin film resistor made of Ge is 2 mm in length at its rectangular cross section is 0.2 mm x 1 mm.

\[ \text{Ge: } p = 6.47 \ \Omega - \text{m} \]

\[ R = \frac{pL}{A} \]

a) Top to Bottom: \[ R = 6.47 \left( \frac{0.2 \text{ mm}}{2 \times 1 \text{ mm}^2} \right) \]

\[ = 0.417 \left( \frac{6.2}{2 \times 16^{-3}} \right) = \frac{4766 \Omega}{\text{m}} \]

b) Front to Back: \[ R = 6.47 \left( \frac{1 \text{ mm}}{2 \times 0.2 \text{ mm}^2} \right) \]
\[
= 0.47 \left( \frac{1}{0.4 \times 10^{-3}} \right) = 1175 \Omega
\]

(Left to Right): \( R = 0.47 \left( \frac{2 \text{mm}}{0.2 \times 1 \text{ mm}^2} \right) \)

\[
= 0.47 \left( \frac{2}{6.2 \times 10^{-3}} \right) = 41760 \Omega
\]

2.7 A 110V heating element in a stove can boil a standard size pot of water in 1.2 minutes, consuming a total of 136kJ of energy. Determine the resistance of the heating element and current flowing through it.

\[
P = \frac{E}{t} = \frac{136 \text{kJ}}{1.2 \text{min}} = \frac{136 \text{kJ}}{72 \text{ sec}} = 1889 \text{ W}
\]

\[1 \text{W} = \frac{J}{s}\]
\[ P = IV = 1689 = 110 \cdot I \quad I = 17.17\, \text{A} \]

\[ R = \frac{V}{I} = \frac{110}{17.17} = 6.41\, \Omega \]

2.11 Select \( R \) so that \( V_L = 9\, V \)

\[ I_0 \quad 12\, V \quad I \]

\[ 3I_0 \]

\[ 500 \]

\[ I_0 \quad \text{(Node 1)} \quad 3I_0 + 500I_0 \quad \rightarrow \quad 12 = R(4m) + 500(4m) \]

\[ \text{Loop 1} \]

\[ 3I_0 + 500I_0 = \frac{9}{500} \]

\[ R = 2500\, \Omega \]

\[ I_0 = 4\, \text{mA} \]

2.17 Find \( I_1, I_2, I_3, I_4 \)

\[ I_1, I_2, I_3, I_4 \]
All parallel so \[ R_{eq} = \frac{1}{2} + \frac{1}{4} + \frac{1}{2} + \frac{1}{2} \]

\[ R_{eq} = 0.67 \Omega \]

\[ V_0 = 6 \cdot R_{eq} = 6 \cdot 0.67 = 4V \]

\( V_0 \) is over all resistors b/c parallel

\[ I_1 = \frac{V_0}{2} = \frac{4}{2} = 2A \]

\[ I_2 = \frac{V_0}{4} = \frac{4}{4} = 1A \]

\[ I_3 = \frac{V_0}{2} = \frac{4}{2} = 2A \]

\[ I_4 = V_0 = 4 \]

Check:

\[ C = I_1 + I_2 + I_3 + I_4 \]

\[ 6 = 2 + 1 + 2 + 1 = 6 \checkmark \]
\[ I_1 = \frac{V_0}{E_1} = \frac{V_1}{E_2} = 1 \text{A} \]

2.19 Determine \( I_x + I_y \)

**Loop 1:**

\[ 10 = 2I_x + 4(I_x-I_y) = 2I_x + 4I_x - 4I_y = 6I_x - 4I_y \]

\[ I_x = \frac{10 + 4I_y}{6} \]

**Loop 2:**

\[ 4I_x = 4(I_y-I_x) + 6I_y = 4I_y - 4I_x + 6I_y = 10I_y - 4I_x \]

Substitute \( I_x \) from above

\[
\left( 4 \left( \frac{10 + 4I_y}{6} \right) = 10I_y - 4 \left( \frac{10 + 4I_y}{6} \right) \right) \]

\[ 40 + 16I_y = 60I_y - 40 - 16I_y \]

\[ 80 = (60 - 16 - 16)I_y \quad I_y = 2.857 \text{A} \]

\[ I_x = \frac{10 + 4(2.857)}{3.571} = 3.571 \text{A} \]
2.23 Determine Power supplied by independent current source

Current through $R_1$ resistor is $i_1 = \frac{V_1}{2}$

Node 1

$6.2 + \frac{V_1}{4} = \frac{V_1}{2} \quad 0.2 = V_1 (0.5 - 0.25) \quad V_1 = 0.8 \text{V}$

$V_5 = (\frac{V_1}{2}). 4 = 2 \cdot V_1 = 1.6 \text{V}$

$P = V_5 \cdot I = 1.6 \cdot 0.2 = 0.32 \text{W}$

2.25 Determine $V_{11}, V_{21}, V_{31}$
\[ V_1 = \frac{3 \cdot 1}{1} = 6 \text{V} \]
\[ V_3 = \frac{3 \cdot 1}{1} = 6 \text{V} \]

For \( V_2 \): looking at node 4

Current \( I_n = \text{current out} \)

With 1A in and 1A out, no current flows through middle 6Ω resistor

So \( V_2 = 0 \cdot 6 = 0 \text{V} \)

2.29 \( I_1 = 1 \text{A} \) Find \( I_0 \)

\( V = 1 \cdot 16 = 16 \text{V} \)

- Current through each resistor
\[ I_0 = \text{current through each resistor} \]
\[ = \frac{16}{1} + \frac{16}{2} + \frac{16}{8} + \frac{16}{16} = 16 + 8 + 4 + 2 + 1 = 31 \text{A} \]

2.34 Find \( R \) so \( V_L = 5 \text{V} \)

![Circuit Diagram]

No current flows through 1k resistor, so voltage over 2k resistor is 5V.
So \( V_2 = 5 \text{V} \)

Current through 2k resistor \( = \frac{V_2}{2k} = \frac{5}{2k} = 2.5 \text{mA} \)

This same current flows through \( R \) at node 1. 5mA goes in and divides in two equal currents (\( i_1 = 2.5 \text{mA} \))
So \( R + 2k = 5k \)  \( R = 3k \text{Q} \)
2.38 Find Req at a, b

The two 5Ω resistors by c+d are not in a loop, so they do not get included.

4Ω ~ all in series

so 3+6+3=12Ω

12Ω in parallel \(\frac{6 \cdot 12}{6 + 12} = 4Ω\)

4Ω → 9Ω