Problems 3.6, 3.18, 3.22:

3.6: Find the equivalent resistances seen by the source in each of the circuits below.

(a)

\[ \text{Req} = \frac{12 \Omega \parallel 28 \Omega}{49} = \frac{12 \cdot 28}{49} \Omega = 6 \Omega \]

(b) Let's redraw circuit to place nodes a + b on left edge
3.6 (b): 

\[ R_{eq} = 14 \Omega \]

(c) 

\[ 75 \text{k}\Omega || 50 \text{k}\Omega = \frac{75 \times 10^3 \times 50 \times 10^3}{125 \times 10^3} = 30 \text{k}\Omega = \frac{100 \text{k}\Omega}{400 \text{k}\Omega} = 75 \text{k}\Omega \]

\[ 30 \text{k}\Omega || 150 \text{k}\Omega = \frac{30 \times 10^3 \times 150 \times 10^3}{180 \times 10^3} = 25 \text{k}\Omega = R_{\|} \]

\[ (or \ G_{\|} = \frac{1}{75000} + \frac{1}{150000} + \frac{1}{150000} = \frac{2 + 3 + 1}{150000} = \frac{6}{150000} = \frac{1}{25000} \] 

\[ R_{\|} = \frac{150000}{6} \Omega = 25 \text{k}\Omega \]

Same answer
3.6 (c) (cont.) Now our circuit looks like:

\[ \begin{align*}
\text{which is a series circuit}
\end{align*} \]

\[ R_{eq} = 75 \Omega + 25 \Omega + 25 \Omega = 125 \Omega = R_{eq} \]

3.18: Select the values of \( R_1, R_2, R_3 \) in the circuit below to meet the following design requirements.

a) Total power 24 V supplied to divide circuit by 24 V source is 80 W when divider is unloaded.

b) \( V_1 = 12 \text{V}, V_2 = 5 \text{V}, V_3 = -12 \text{V} \) measured w.r.t. common reference terminal.

From a), \( P_{ul} = 80 \text{W} \). When unloaded, circuit looks as above, with nothing attached to \( V_1, V_2 \) or \( V_3 \) terminals. Thus \( R_{eq} = R_1 + R_2 + R_3 \)

\[ P_{ul} = V^2 / R_{eq} = (24)^2 / (R_1 + R_2 + R_3) = 576 / (R_1 + R_2 + R_3) = 80 \text{W} \]

\[ R_1 + R_2 + R_3 = \frac{576}{80} \approx 7.2 \Omega \]

We can use the voltage divider equations to solve for \( V_1, V_2, V_3 \). Note that all voltages are w.r.t. common reference terminal, so:

\[ \begin{align*}
V_1 &= V_2 + V_3,
V_2 &= \frac{R_2}{R_1 + R_2 + R_3} V_1
\end{align*} \]
3.18 (cont.): \( V_1 \) is taken across \( R_1 + R_2 \). By voltage divider, \( V_1 = V_S \frac{R_1 + R_2}{R_1 + R_2 + R_3} = \frac{24(R_1 + R_2)}{R_1 + R_2 + R_3} = 12 \text{ V} \)

or \( 2(R_1 + R_2) = R_1 + R_2 + R_3 \)

Similarly, \( V_2 = V_S \frac{R_2}{R_1 + R_2 + R_3} \)

or \( \frac{24}{5} R_2 = R_1 + R_2 + R_3 \); \( 4.8 R_2 = R_1 + R_2 + R_3 \)

Note that \( V_3 \) has the direction of its voltage rise opposite that of \( V_1 + V_2 \). Using Kirchhoff's voltage law, we obtain

\[ V_3 = V_S \frac{R_3}{R_1 + R_2 + R_3} \]

or \( V_3 = \frac{-24 R_3}{R_1 + R_2 + R_3} = -18 \text{ V} \)

or \( 2R_3 = R_1 + R_2 + R_3 \)

\[ R_3 = \frac{R_1 + R_2 + R_3}{2} = 3.6 \Omega \]

\[ 4.8 R_2 = R_1 + R_2 + R_3 \]

or \( R_2 = \frac{7.2 - R_3}{4.8} = 1.5 \Omega \)

\[ R_1 + R_2 + R_3 = 7.2 \Omega \]

\[ R_1 = 7.2 - R_2 - R_3 = 7.2 - 5.1 \Omega = 2.1 \Omega \]

\( R_1 = 2.1 \Omega \)
\( R_2 = 1.5 \Omega \)
\( R_3 = 3.6 \Omega \)

3.22: Given the circuit below:

(a) Use current division to find the current flowing from top to bottom in the 10 k\( \Omega \) resistor.
3.22 (cont.): First, reduce the rest of the circuit to an equivalent resistance in parallel with the 10kΩ resistor.

\[
\text{Reg} = \frac{(3kΩ + 8kΩ) + 6kΩ}{15kΩ} = 4kΩ
\]

\[
\text{Reg} = 11kΩ + 4kΩ = 15kΩ
\]

By current division,

\[
i_{0e} = I_s \frac{15kΩ}{10kΩ + 15kΩ} = 0.5\text{mA}(15kΩ)
\]

\[
i_{0e} = \frac{0.5\text{mA}}{5\text{mA}} = 0.12\text{mA}
\]

b) Using your result from (a), find the voltage drop across the 10kΩ resistor, positive at the top.

\[
V_{10k} = i_{0e} R = (0.12\text{mA})(10kΩ) = 1.2\text{mV}
\]

(Note that mA = 10⁻³ A and kΩ = 10³ Ω, so mA/kΩ = A:Ω = V)

c) Using your result from (b), use voltage division to find the voltage drop across the 6kΩ resistor, positive at the top.

We know that \(V_{10k} = 1.2\text{mV}\).

We want to find \(V_{6k}\), which is also the voltage drop across the 5kΩ + 7kΩ resistors. \(V_{6k}\) is the voltage drop across the parallel combination of 6kΩ + 5kΩ + 7kΩ = 18kΩ. The equivalent resistance of this parallel combination is \(\text{Reg} = \frac{6000(12000)}{18000} = 4kΩ\).
Our voltage divider looks like:

\[ V = \frac{12 \times 4000}{11000+4000} = 3.2 \text{V} \]

d) Using your result from (c), use voltage division to find the voltage drop across the 5kΩ resistor positive at the left.

By voltage division,

\[ V_{5k} = \frac{V(5kΩ)}{5kΩ+7kΩ} = \frac{3.2(5)}{12k} \text{V} \]

\[ V_{5k} = 1.33 \text{V} \]