1) Discuss series vs. parallel equivalent resistance

**Series** - means they share a common node in the middle and nothing else touches that node

\[
\frac{1}{\frac{1}{R_a} + \frac{1}{R_b}} = \frac{1}{\frac{1}{R_{eq}}} = R_a + R_b
\]

**Parallel** - means the resistors both connect the same two nodes

\[
\frac{1}{\frac{1}{R_a} + \frac{1}{R_b}} = R_{eq} = \frac{R_a R_b}{R_a + R_b}
\]

2) Problem 2.13

Find equivalent resistance

- 30 is \(11\) to \(Z\), 60 \(11/40\)

\[
\frac{1}{\frac{1}{R_{eq}}} = \frac{1}{\frac{1}{20} + \frac{1}{30}} = 12 \Omega
\]

\[
\frac{1}{\frac{1}{R_{eq}}} = \frac{1}{\frac{1}{60} + \frac{1}{40}} = 24 \Omega
\]
4 is in series with 12

\[ \frac{1}{4} + \frac{1}{12} = \frac{9}{12} = \frac{3}{4} \]

\[ 4 + 12 = 16 \]

16 is in parallel with 24

\[ \frac{1}{16} + \frac{1}{24} = \frac{1}{16} + \frac{1}{24} = \frac{9}{96} = 9.652 \]

Final solution:

9.652
3) Discuss voltage/current dividers

Voltage divider

\[ V_{\text{tot}} \]

\[ V_3 = V_{\text{tot}} \frac{R_3}{R_1 + R_2 + R_3 + R_4} \]

Voltage across any single resistor is of the form:

Current divider

\[ i_1 = \frac{i_{\text{tot}}}{i_1} \frac{R_2}{R_1 + R_2} \]

Current through any single resistor is of the form:
4) Problem 2.18 - using voltage divider + equivalent resistance

\[ \text{Diagram:} \]

Find \( v_1 \) and \( v_2 \)

- First find \( v_1 \). Notice that 25 \( \Omega \) is in series with 6 \( \Omega \)
  \[ R_{eq} = 30 \Omega \]

\[ \text{Diagrams:} \]

Elements in parallel have same voltage across them, so we can move \( v_1 \) anywhere we like. Consider:

\[ \text{Diagram:} \]

Now \( 10 \parallel 30 \parallel 30 \).

\[ 10 \parallel \frac{30}{30} = \begin{cases} \frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{30} + \frac{1}{30} = 6 \Omega \end{cases} \]
This is just a simple voltage divider

\[ V_1 = 12 \frac{6}{12+6} = 4 \text{ V} \]

Now find \( V_2 \). Again, this is a voltage divider since we know the voltage across \( \frac{25}{5} \)

\[ V_2 = 4 \frac{5}{5+25} = \frac{4}{6} \text{ V} = \frac{2}{3} \text{ V} \]

5) **KCL — basis for nodal analysis**

Sum of currents entering a node is equal to the sum of the currents leaving a node

6) **Problem 2.38 — as an example of KCL**

Find \( v_1, v_2, i \)

- Step 1: Define all reference currents through all circuit elements
  - Doesn't matter which way the arrow points so long as you're consistent
(The fact that $i_2$ goes down and $i_3$ up is arbitrary)

- **Step 2: KCL equations**
  - For upper left node:
    \[ \sum m = \sum \text{out} \]
    \[ 1 = \dot{i}_1 + \dot{i}_2 \]
  - For upper right node:
    \[ \sum m = \sum \text{out} \]
    \[ \dot{i}_1 + \dot{i}_3 + 2 = 0 \]
  - For bottom node:
    \[ \sum m = \sum \text{out} \]
    \[ \dot{i}_2 = 1 + \dot{i}_3 + 2 \]

- **Step 3: Ohm's law**

  \[ I = \frac{V}{R} \]

  For $i_1$: the $V$ is the voltage drop across the 10Ω current flows from high voltage to low, so $V_i > V_2$

  \[ \Rightarrow V = V_i - V_2 \]

  \[ \dot{i}_1 = \frac{V_i - V_2}{10} \]

  For $i_2$: $V = V_1 - 0$

  \[ \dot{i}_2 = \frac{V_1}{20} \]

  For $i_3$:

  $V = 0 - V_2$

  \[ \dot{i}_3 = \frac{-V_2}{5} \]
Step 4: gather up all equations and solve

\[ i = i_1 + i_2 \]
\[ i_1 + i_2 + 2 = 0 \]
\[ i_2 = 1 + i_3 + 2 \]
\[ i_1 = \frac{V_1 - V_2}{10} \]
\[ i_2 = \frac{V_1}{20} \]
\[ i_3 = \frac{-V_2}{5} \]

Solving, we get:

\[ i_1 = 0.286 \text{ mA} \]
\[ i_2 = 714 \text{ mA} \]
\[ i_3 = -2.286 \text{ A} \]
\[ V_1 = 14.3 \text{ V} \]
\[ V_2 = 11.4 \text{ V} \]

What does the minus sign on \( i_3 \) mean? It means the current flows the opposite way.