**Electrical**

- Voltage - volts
- Current - amperes
- Power - watts

Ohm's Law: \( V = IR \)

Kirchhoff's Voltage Law (KVL):

- Sum of voltage drops around any closed loop = 0

Kirchhoff's Current Law (KCL):

- Sum of currents flowing out of any closed surface (or node) = 0

Circuit with sources, resistors, wires:

\[ I_1 + I_2 - I_3 = 0 \]
Power into element or closed surface \( P_{\text{in}} = VI \)

Load convention

(\text{sign convention is} \ I \ \text{into} \ \oplus \ \text{terminal})

\begin{align*}
\text{Series Resistors, Share the same current.} \\
\uparrow \quad + & \quad \downarrow V \\
V_1 &= IR_1, \ V_2 = IR_2, \ V_3 = IR_3 \\
\downarrow \quad + & \quad \downarrow V \\
V_2 &= \frac{V_1 + V_2 + V_3}{R_1 + R_2 + R_3} \\
\downarrow \quad + & \quad \downarrow V \\
V_3 &= \frac{V_1 + V_2 + V_3}{R_2} \\
\text{Same to outside world as} & \\
\uparrow \quad + & \quad \downarrow V \\
\text{Reqeui} = R_1 + R_2 + R_3 & \quad \text{ Reqequiv is always bigger than the biggest R} \\
\downarrow \quad + & \quad \downarrow V \\
\text{Voltage Divider for Series Resistors says} & \\
\text{voltage drop is proportional to } R & \\
V_2 = IR_2 = \frac{V}{R_1 + R_2 + R_3} \cdot R_2 = V \left[ \frac{R_2}{R_1 + R_2 + R_3} \right] \\
\text{The largest } R \text{ has the most voltage and the most power (by } P = I^2 R) \end{align*}
Parallel resistors share the same voltage

\[ \text{KCL says} \quad -I_1 + I_2 + I_3 = 0 \quad \text{so} \quad I = I_1 + I_2 + I_3 \]

Ohm's Law, \( I_1 = \frac{V}{R_1} \), \( I_2 = \frac{V}{R_2} \), \( I_3 = \frac{V}{R_3} \)

\[ I = I_1 + I_2 + I_3 \Rightarrow I = V \left[ \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right] \]

What is \( \text{Reqiv} \)?

\[ \text{Reqiv} = \frac{V}{I} \]

So

\[ \frac{1}{\text{Reqiv}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \]

\[ \text{Reqiv} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \]

Common case, \( R_1 \& R_2 \),

\[ \frac{1}{\text{Reqiv}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2} \]

So

\[ \text{Reqiv} = \frac{R_1 R_2}{R_1 + R_2} \]

Common case, \( N \) identical \( R \)s in parallel

\[ \frac{1}{\text{Req}} = \frac{1}{R} + \frac{1}{R} + \cdots + \frac{1}{R} = \frac{N}{R} \]

\[ \text{Req} = \frac{R}{N} \]

The parallel combo of resistors is always less than the smallest of the \( R \).

The smallest \( R \) gets the most \( P = \frac{V^2}{R} \).
KVL (sum of voltage drops around closed loop)

\[-V_{1,0} + V_{1,8} + V_{8,0} = 0\]

so \[V_{1,8} = V_{1,0} - V_{8,0}\].

Thus, you get \(V_{1,8}\) by placing the red voltmeter lead on \(1\), and the black voltmeter lead on \(8\).

Or

Measure \(V_{1,0}\) (red on \(1\), black on \(0\))

Measure \(V_{8,0}\) (red on \(8\), black on \(0\)).

Then \[V_{1,8} = V_{1,0} - V_{8,0}\] (same result)
What impact does this change have in your lab calculations?

\[ KCL \text{ Says} \quad I = 0 \]
\[ \text{NEW \quad ground \quad REF \quad voltage} \quad = 0 \]

Add \[ 10\text{KV} \]

Answer: None. All node voltages rise by 10KV, but \( V_{1,8} \) and relative voltages within your circuit are unchanged.

What impact does this change have in your lab notes?

\[ \text{OLD} \quad V = 0 \quad \text{REF} \]
\[ \text{NEW} \quad V = 0 \quad \text{REF} \]

Answer: None. You can add the same \( V \) to every node, and no current changes.

So, subtract the old \( V_{4,0} \) from every node voltage to make \( V_{4,0} = 0 \).

Old \( V_{\text{REF}} \) becomes \(-V_{4,0 \text{ old}}\).

Study PCB Ckt. Book Chapter 9, Sections 1-5. HW5 problems.