Physics 231

Lecture 2: Resistor Circuits

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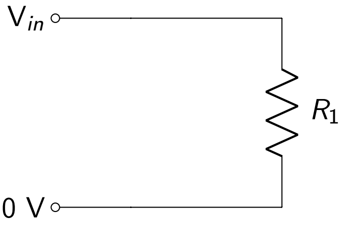
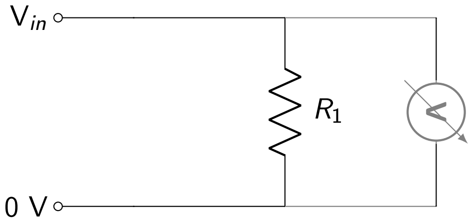
Single Resistor Circuit:



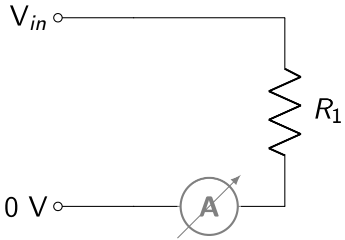
$$V = IR \tag{1}$$

$$P = IV \tag{2}$$

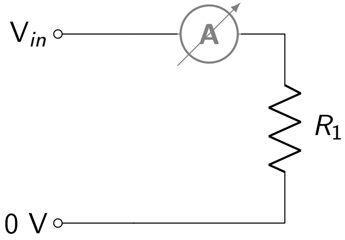
Single Resistor Circuit: Measuring Voltage



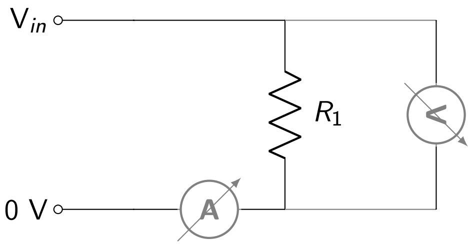
Single Resistor Circuit: Measuring Current



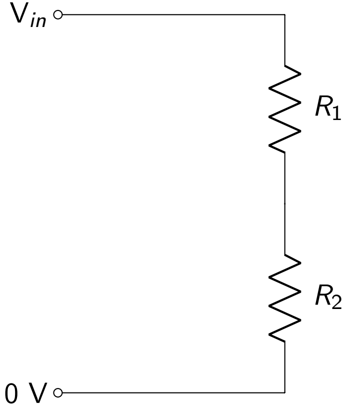
or



Single Resistor Circuit: Measuring Voltage and Current



Equivalent Resistor Circuits: Resistors in Series

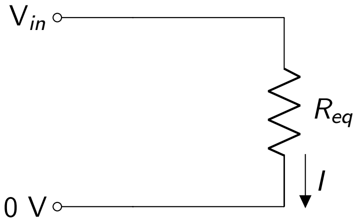


Equivalent Resistor Circuits: Resistors in Series

1. Convert a more complicated arrangement or resistors into a simpler arrangement for easier calculations.

$$R_{eq} = R_1 + R_2 \tag{3}$$

$$I = \frac{V_{in}}{R_{eq}} \tag{4}$$

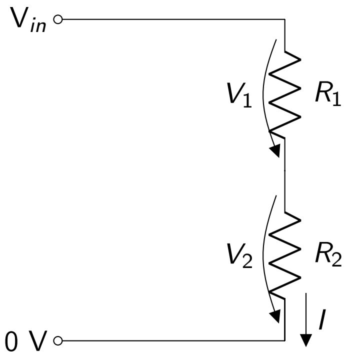


Equivalent Resistor Circuits: Resistors in Series

2. Apply these results to the more complex configuration.

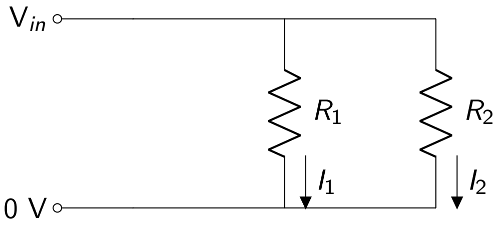
$$V_1 = IR_1 = \left(\frac{V_{in}}{R_{eq}}\right) R_1 = \frac{R_1}{R_1 + R_2} V_{in} \tag{5}$$

$$V_2 = IR_2 = \left(\frac{V_{in}}{R_{eq}}\right) R_2 = \frac{R_2}{R_1 + R_2} V_{in} \tag{6}$$



Equivalent Resistor Circuits: Resistors in Parallel

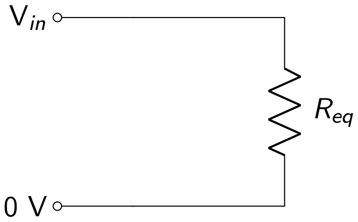
The voltage is the same across both resistors, but each has a different current.



Equivalent Resistor Circuits: Resistors in Parallel

Convert the parallel resistor configuration into a single equivalent resistor.

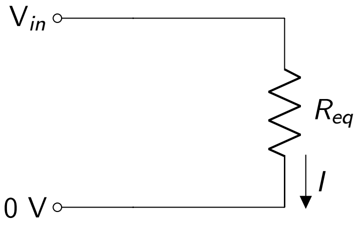
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{7}$$



Equivalent Resistor Circuits: Resistors in Parallel

Calculate the current through the entire circuit.

$$I = \frac{V_{in}}{R_{eq}} = V_{in}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \tag{8}$$



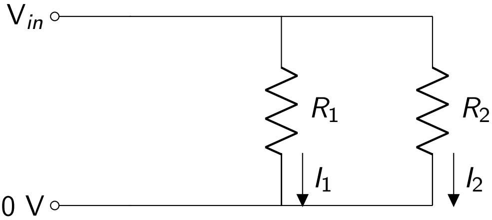
Equivalent Resistor Circuits: Resistors in Parallel

Use the fact that all voltages are the same to calculate the current through each resistor.

$$V_{in} = I_1 R_1 = I_2 R_2 = I R_{eq} \tag{9}$$

and therefore

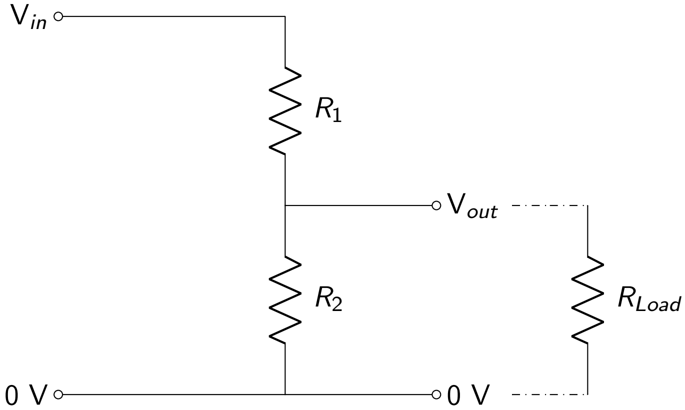
$$I_1 = I \frac{R_{eq}}{R_1} = \frac{V_1}{R_1}, \quad I_2 = I \frac{R_{eq}}{R_2} = \frac{V_2}{R_2} \tag{10}$$



Verify that the currents add up: $I = I_1 + I_2$.

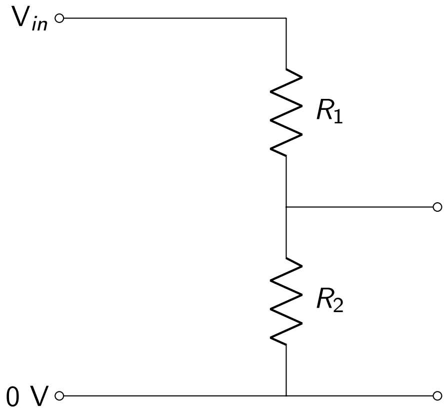
Equivalent Resistor Circuits: Loaded Voltage Divider

Goal: Determine current and voltage (and power dissipation) through each resistor with and without the load resistor connected.



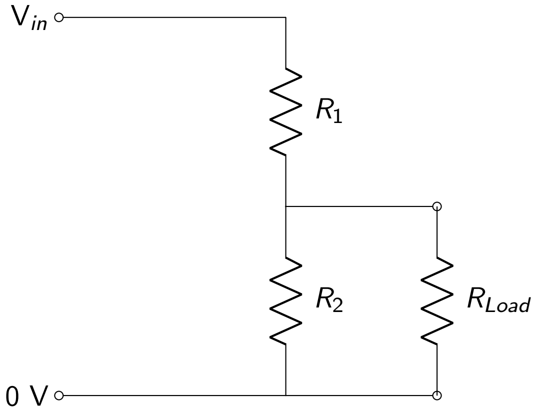
Equivalent Resistor Circuits: Loaded Voltage Divider

Case I: Unloaded (refer back to Resistors in Series)



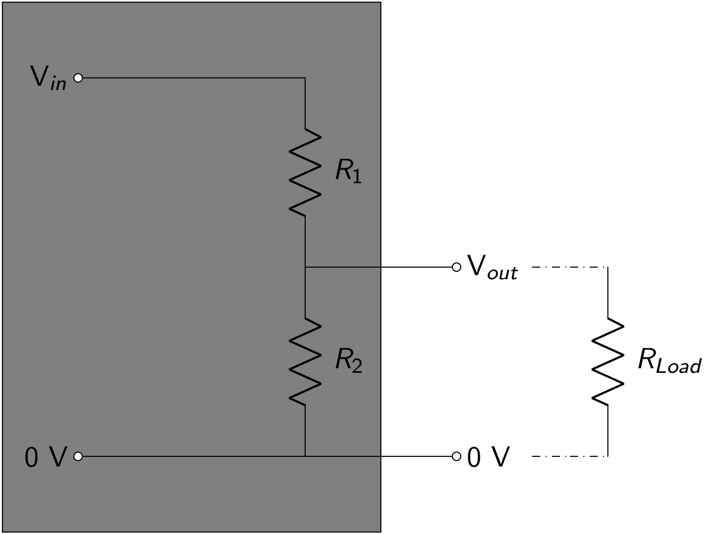
Equivalent Resistor Circuits: Loaded Voltage Divider

Case II: Loaded (refer back to Resistors in Parallel, *then* Resistors in Series)



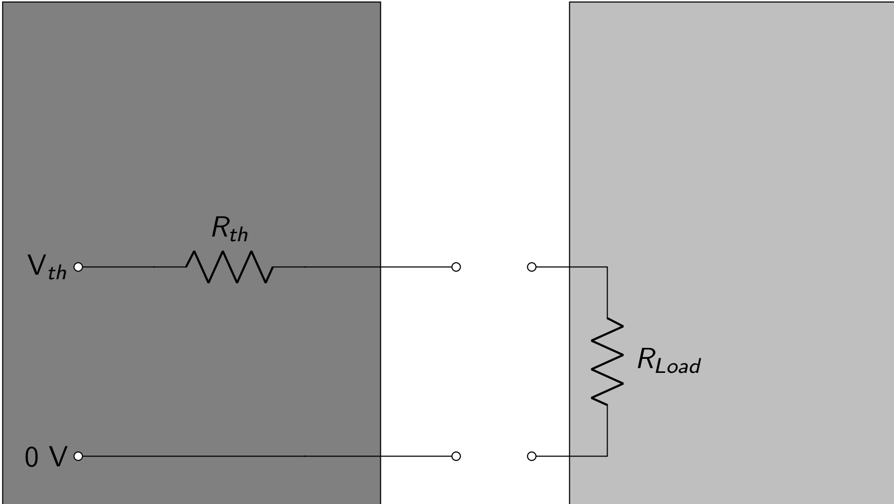
Equivalent Circuits: Voltage Divider

Replace the entire source with a "black box" with an equivalent voltage and an equivalent resistance in series.



Equivalent Circuits: Voltage Divider

The "Thevenin Equivalent" Circuit is defined to be the one where the output voltage $V_{out} = \frac{V_{th}}{2}$ when connected to a load $R_{Load} = R_{th}$. *Every power supply has a V_{th} and R_{th}.*



Equivalent Circuits: Voltage Divider

Questions:

1. What is the V_{th} and R_{th} for the simple voltage divider power supply?
2. What is R_{th} for a "good supply"?
3. What is R_{Load} for a "good load"?
4. What is a disadvantage of a "good supply" made with simple voltage divider?