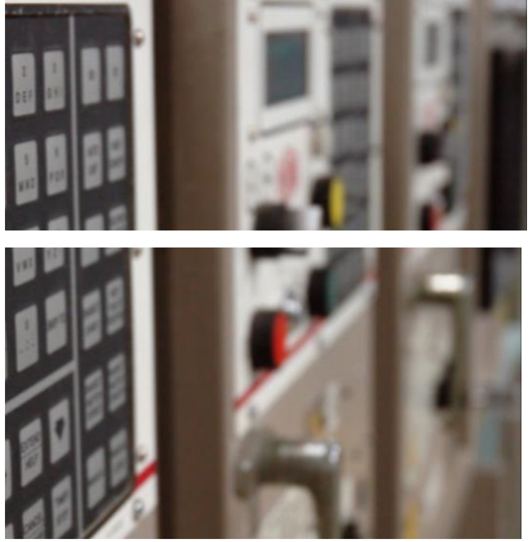

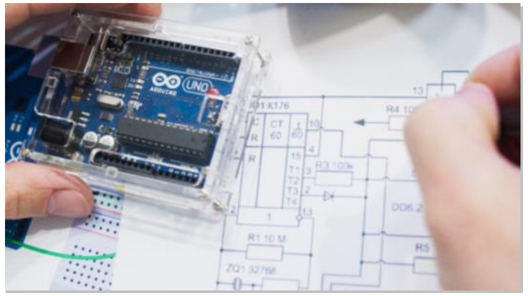

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pathways to engineering technology employment

Bridge Circuits

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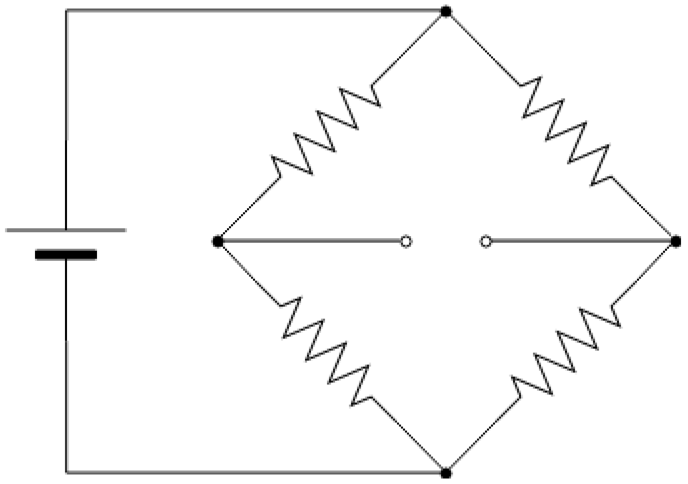
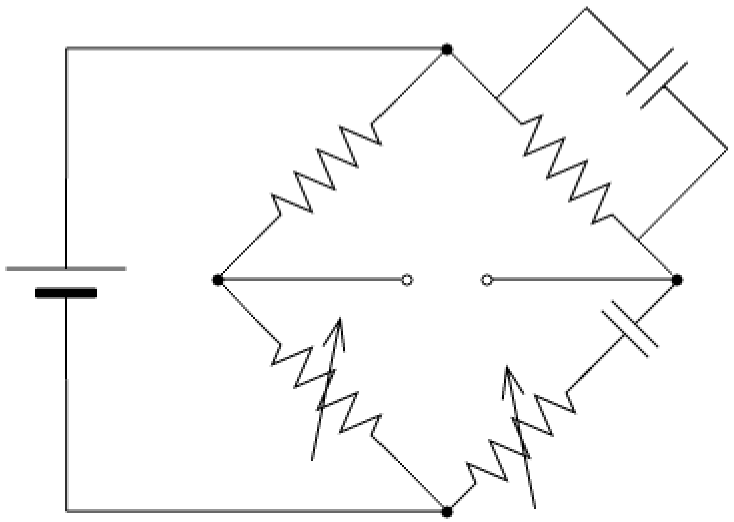
Bridge Circuits

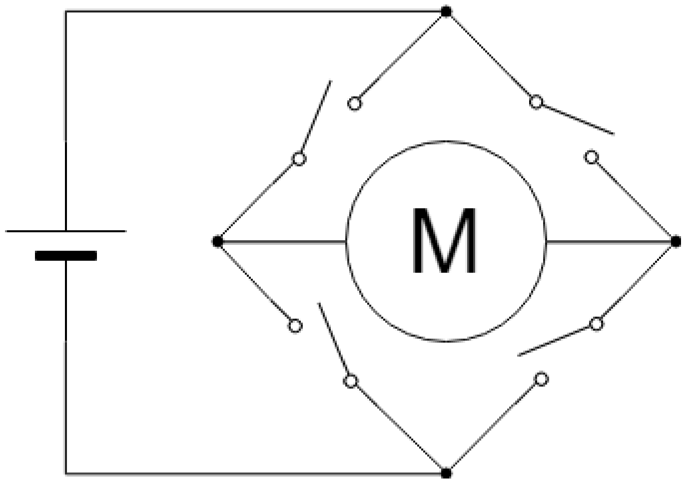
- A bridge circuit is a specific type of circuit that has a bridging section usually between two parallel sections.
- Here are several common types of bridge circuits.



Wheatstone Bridge



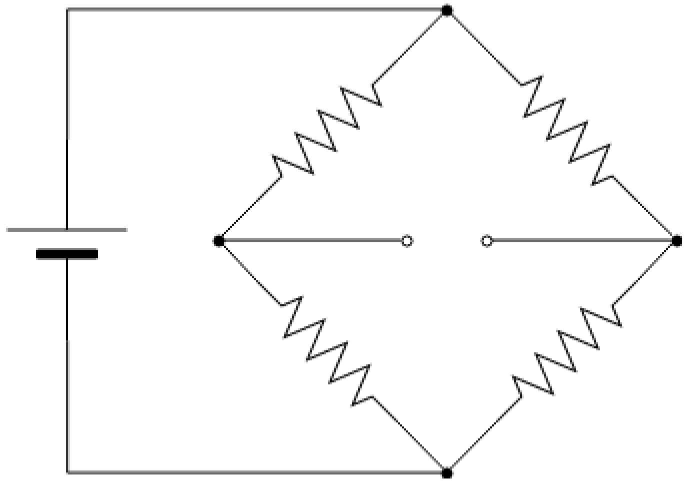
Wien Bridge

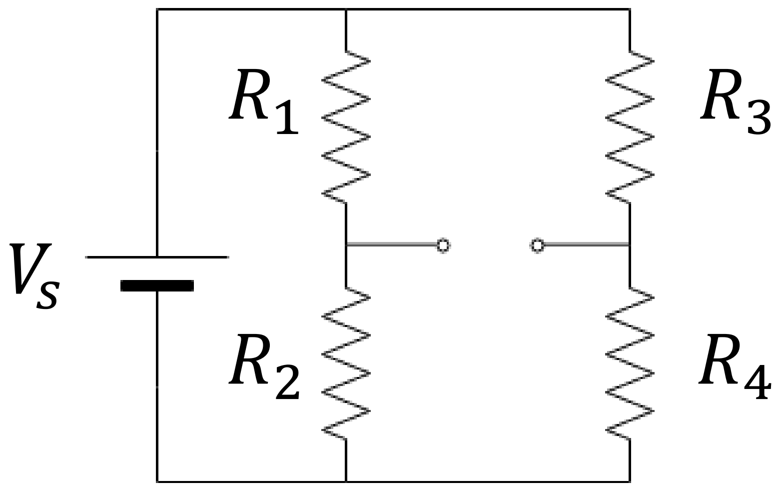


H Bridge

Wheatstone Bridge

- The Wheatstone Bridge is probably the most common type of bridge circuit.
- It is used in numerous applications:
  - Digital Scales (i.e. digital bathroom scales, postage scales, etc.)
  - Ohmmeters
  - Load cells (used in tensile testing machines)
- Let’s look how the circuit works by first simplifying and labeling it.





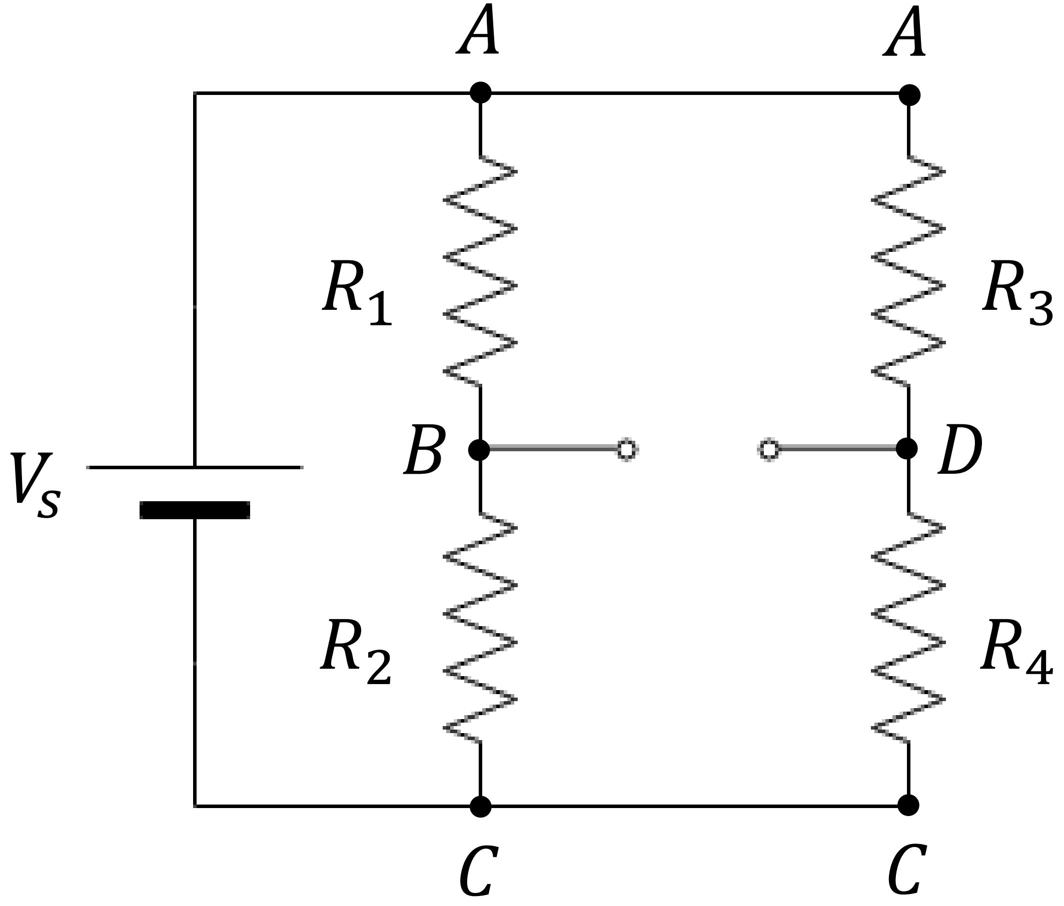
Wheatstone Bridge

- It can be seen in this new arrangement the bridge circuit is just two voltage divider circuits in parallel.
- The supply voltage V_s is called the excitation voltage.
- Let's label the various nodes now.
- The current through ABC is

$$I_{ABC} = \frac{V_s}{R_1 + R_2}$$

- Likewise, the current through ADC is

$$I_{ADC} = \frac{V_s}{R_3 + R_4}$$



Wheatstone Bridge

- The voltage at nodes B and D may then be found by

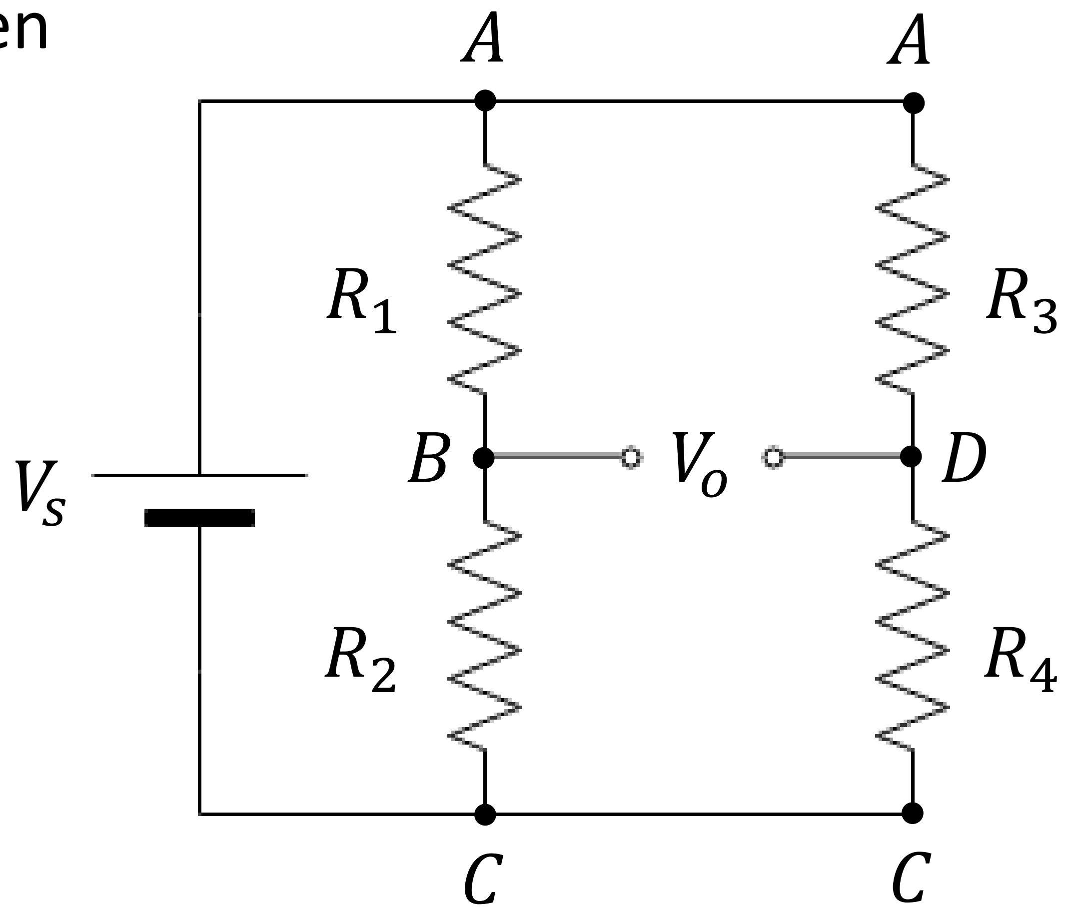
$$V_B = I_{ABC}R_2 = \frac{V_sR_2}{R_1 + R_2} \quad \text{and} \quad V_D = I_{ADC}R_4 = \frac{V_sR_4}{R_3 + R_4}$$

- The voltage between the two nodes is then

$$V_o = V_D - V_B = \frac{V_sR_4}{R_3 + R_4} - \frac{V_sR_2}{R_1 + R_2}$$

$$= V_s\frac{R_1R_4 - R_2R_3}{(R_1 + R_2)(R_3 + R_4)}$$

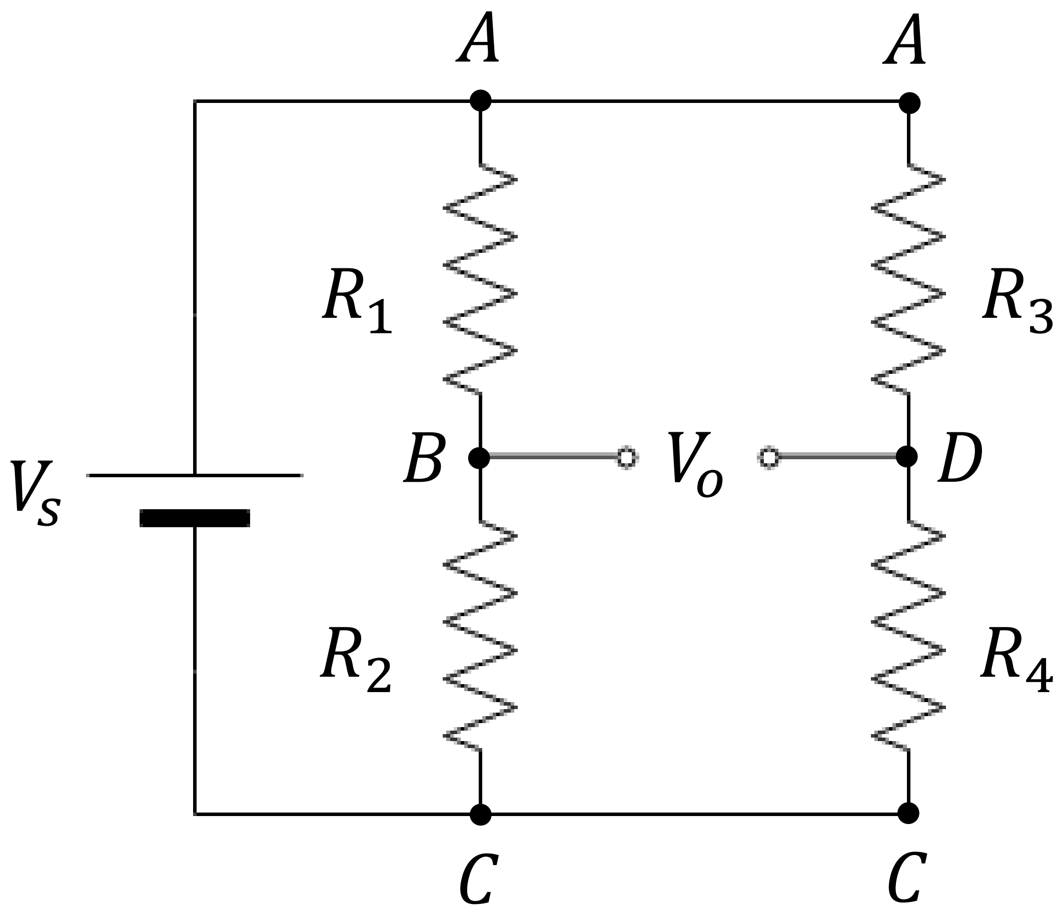
- V_o is known as the output voltage.



Wheatstone Bridge

- Let's look at some special cases of the circuit.
- What is V_o when $R_1 = R_2 = R_3 = R_4$?
  - $V_o = 0V$
  - When the output voltage is zero, the circuit is said to be balanced.
- What is V_o when $R_1 = R_2 = R_3 \neq R_4$?
  - $V_o \neq 0V$
  - When the output voltage is not zero, the circuit is said to be unbalanced.
  - This imbalanced can be related to the amount of change that is experienced in R_4.

$$V_o = V_s \frac{R_1 R_4 - R_2 R_3}{(R_1 + R_2)(R_3 + R_4)}$$



Wheatstone Bridge

- Let's denote the starting value of R_4 as R_0.

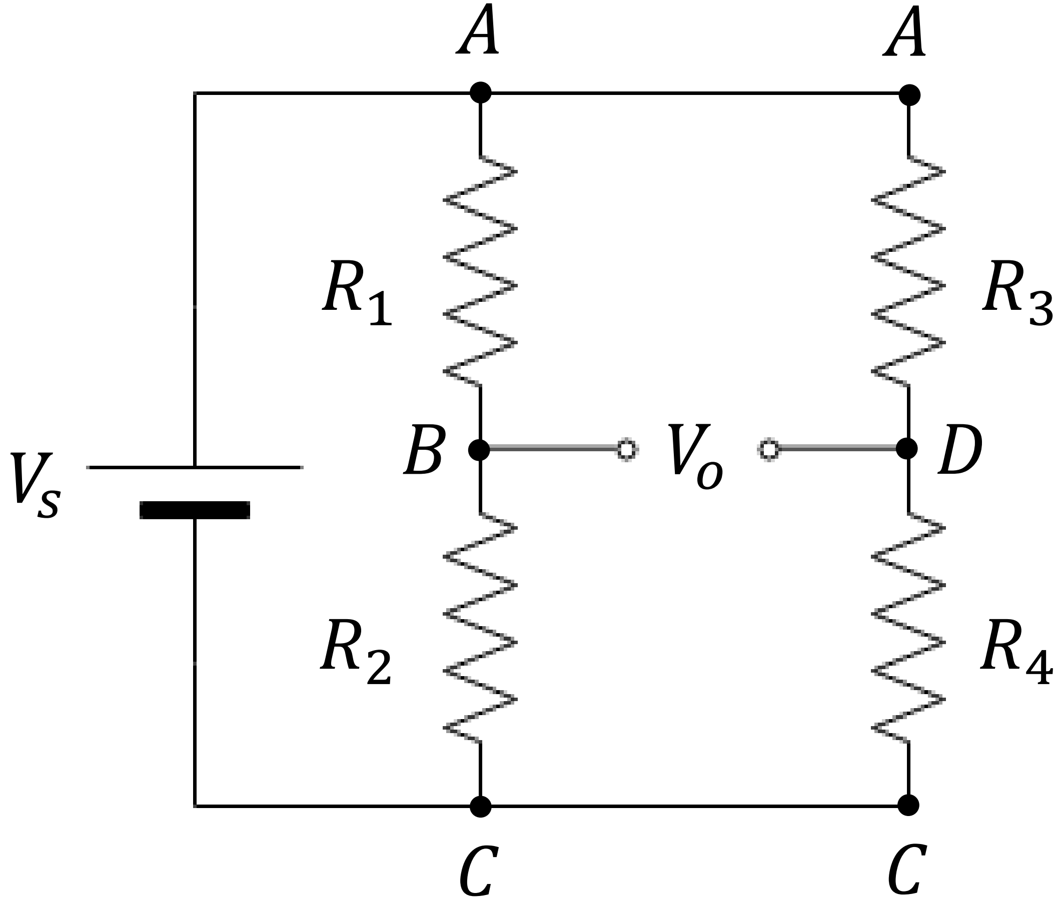
  $R_4 = R_0 + \Delta R_4$

  where ΔR_4 is the amount of change in R_4.
- V_o is then

  $$V_o = V_s \frac{R_1(R_0+\Delta R_4)-R_2R_3}{(R_1+R_2)[R_3+(R_0+\Delta R_4)]}$$
- Solving for ΔR_4 shows

  $$\Delta R_4 = \frac{V_S(R_1R_0-R_2R_3)-V_O(R_1+R_2)(R_3+R_0)}{V_0(R_1+R_2)-V_SR_1}$$

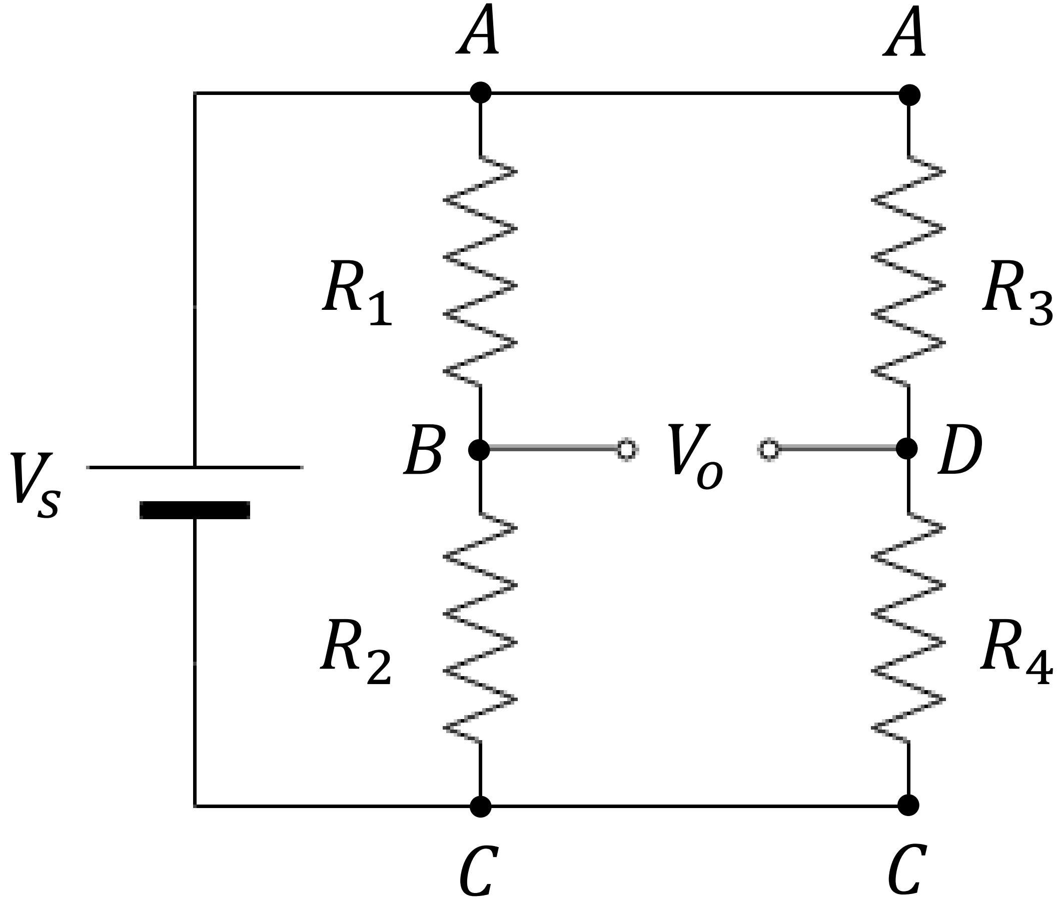
$$V_o = V_s \frac{R_1R_4 - R_2R_3}{(R_1+R_2)(R_3+R_4)}$$



Wheatstone Bridge

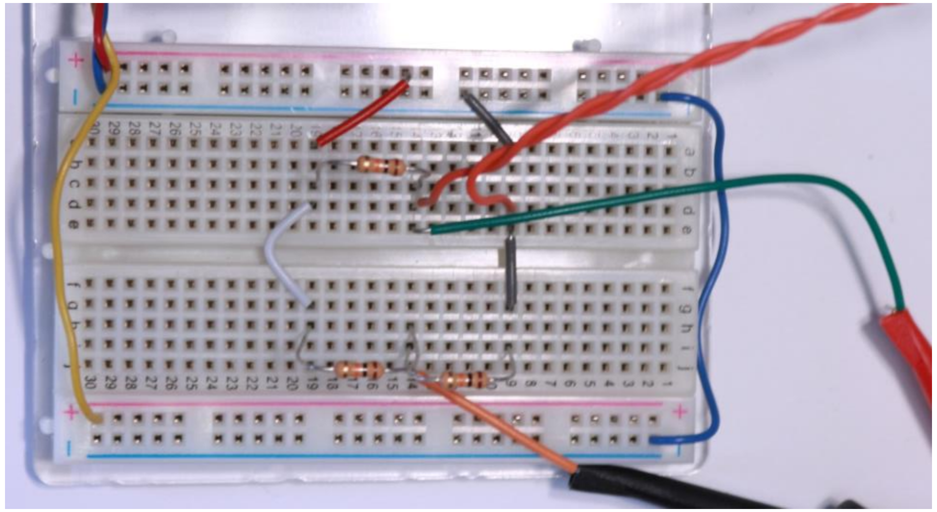
- Why is this important/useful?
  - A lot of sensors change their resistance based on the conditions they are experiencing (for example, the thermistor).
  - The Wheatstone Bridge can be used to measure these changes in resistance.
- Why not just use a simple voltage divider circuit?
  - A simple voltage divider circuit is sensitive to slight unintended changes in resistance in either the top or bottom resistors.
  - The Wheatstone Bridge overcomes this issue by being somewhat self balancing.
  - That is the circuit auto adjusts to unintended changes in resistances.

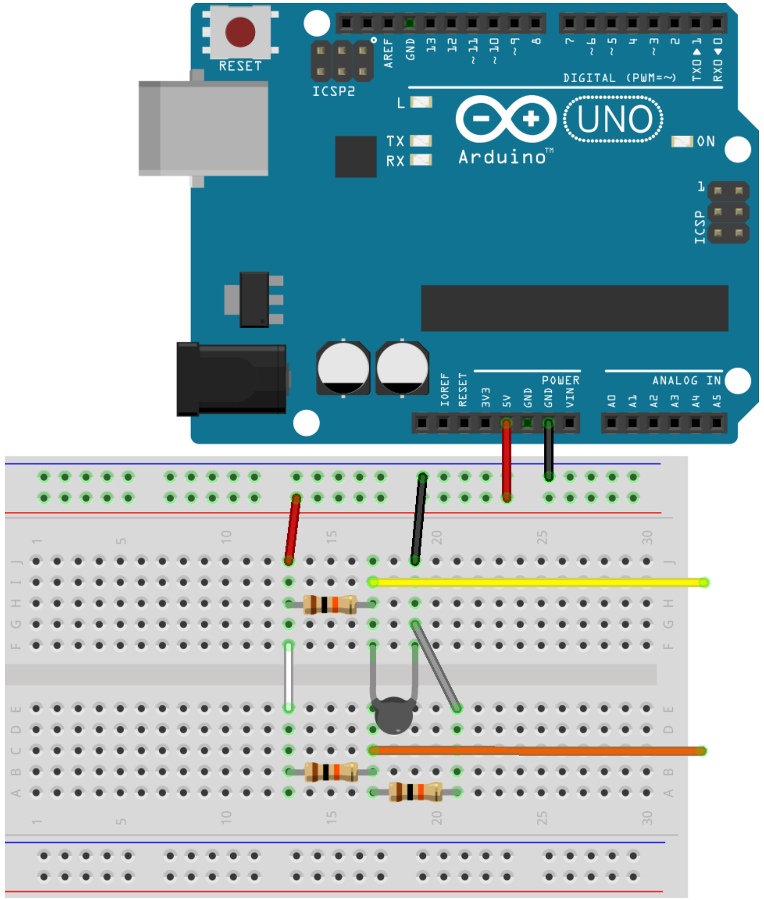
$$V_o = V_s \frac{R_1 R_4 - R_2 R_3}{(R_1 + R_2)(R_3 + R_4)}$$



Let’s Build The Circuit

- Build a Wheatstone bridge circuit using three $10k\Omega$ resistors and your thermistor as shown below.

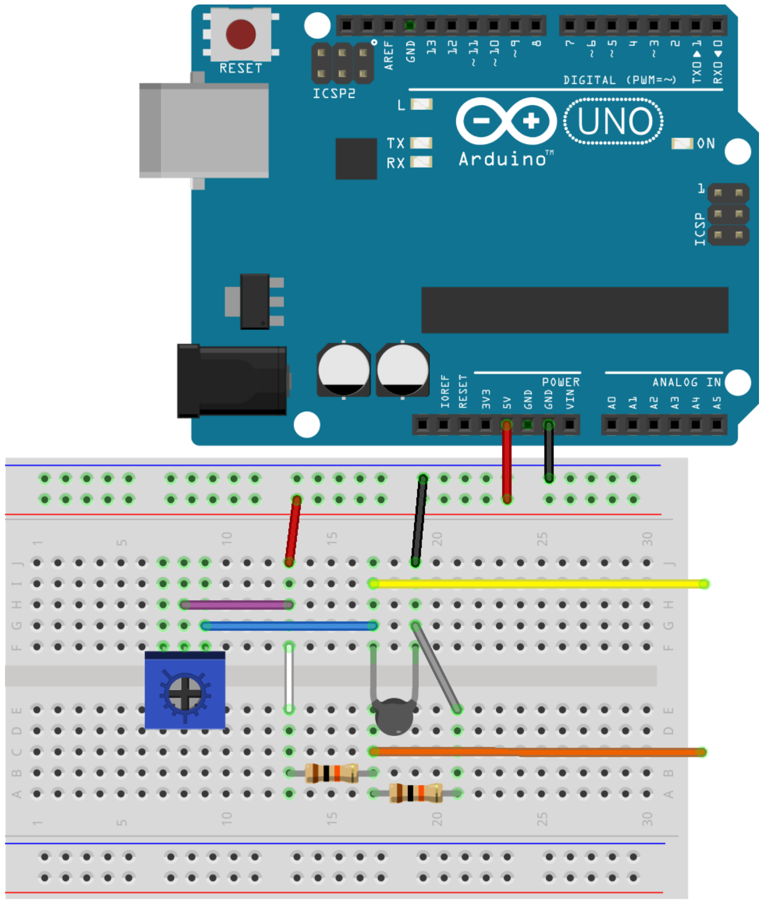


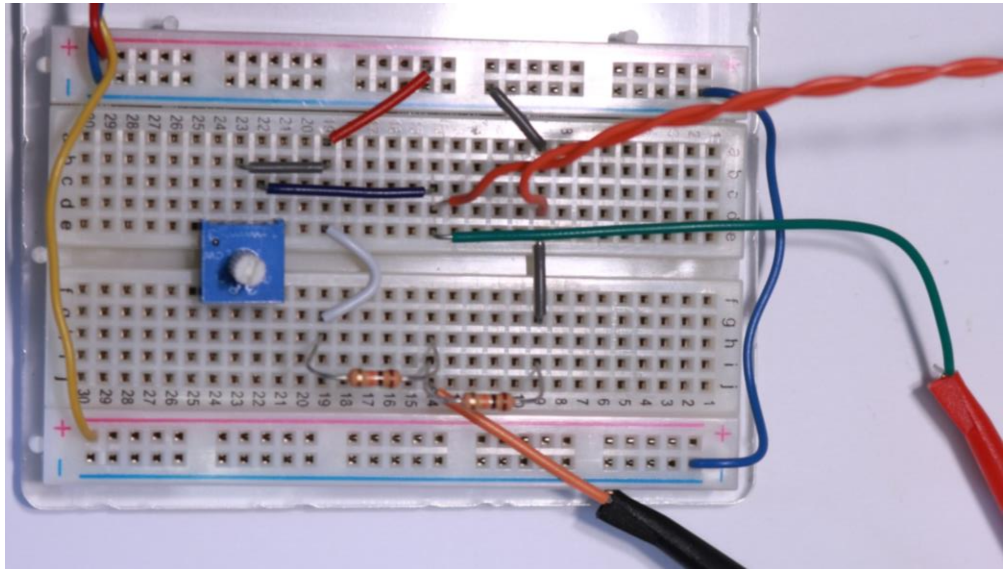


- Connect your multimeter to the yellow and orange wires depicted in the image to the right.
- With multimeter set to reading DC voltage, what does it read?
- Is the bridge circuit balanced?

Let’s Build The Circuit

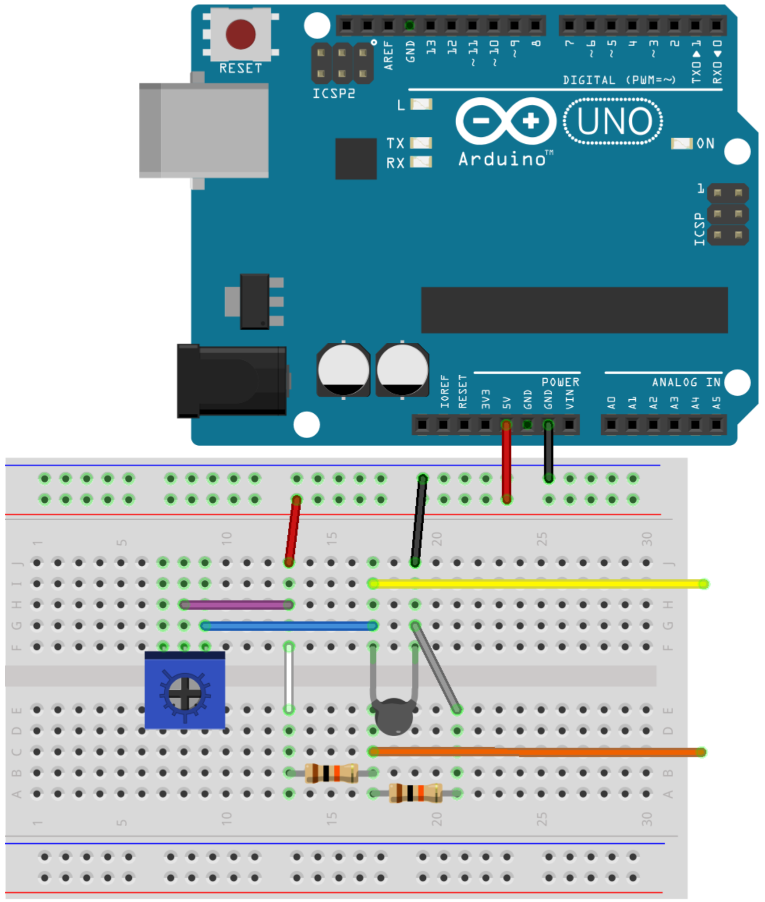
- More than likely, your circuit is not balanced. Why?
- What can we do to make it balanced?
- Using a potentiometer, we can balance the circuit ourselves without the need to obtain resistors that are exactly the same resistance values.
- Build the circuit shown below using the potentiometer in place of R_3.





Let’s Build The Circuit

- Now that the potentiometer is implemented, adjust the potentiometer until the multimeter reads zero.
- Once the multimeter reads zero volts, the bridge is balanced.
- What happens now when you touch the thermistor?
- What happens when you make the thermistor colder?



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