LAB 6

MACROSCOPIC CIRCUIT ANALYSIS

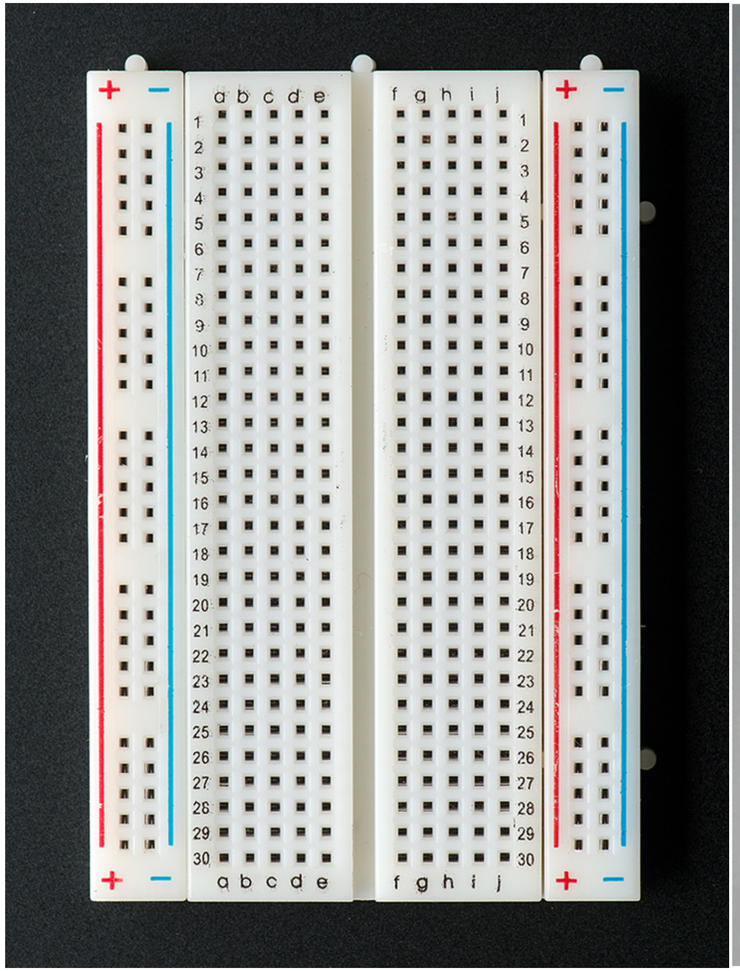
OVERVIEW

Main point of today's lab:

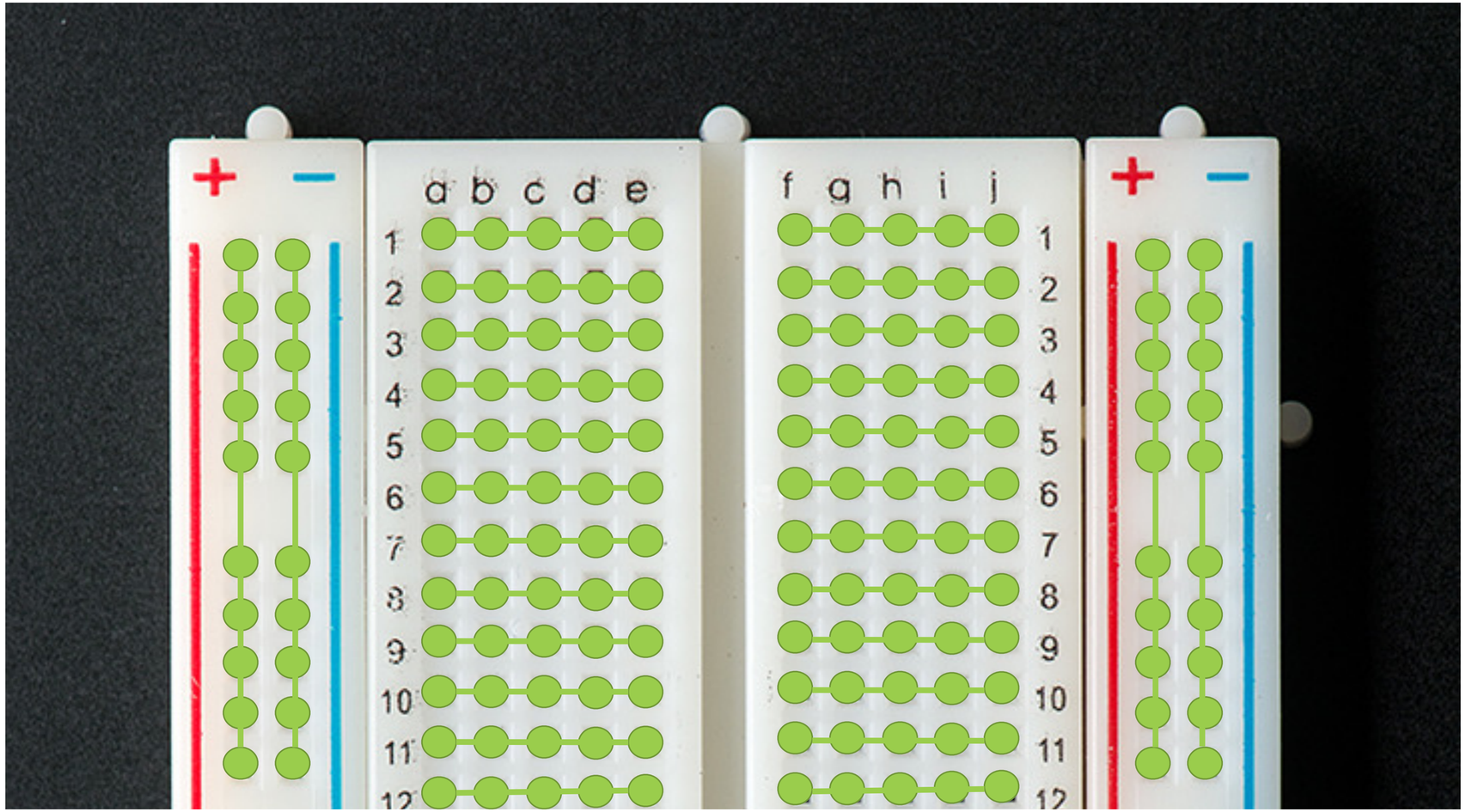
- Build different types of resistor circuits
- Use the loop/node rule to predict the current and voltage of each resistor
- Measure the current and voltage of each resistor, and compare results

BREADBOARDS

- We will build our circuits on breadboards and power them with 9V batteries



BREADBOARDS



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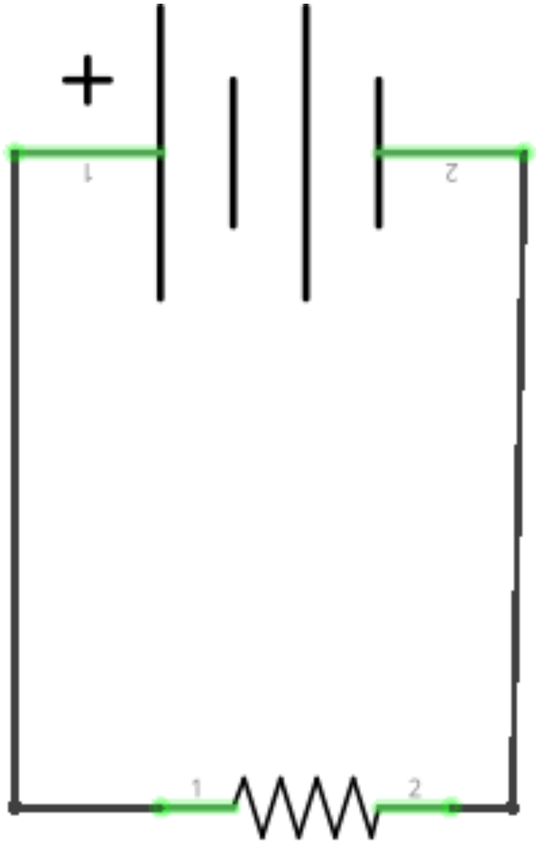

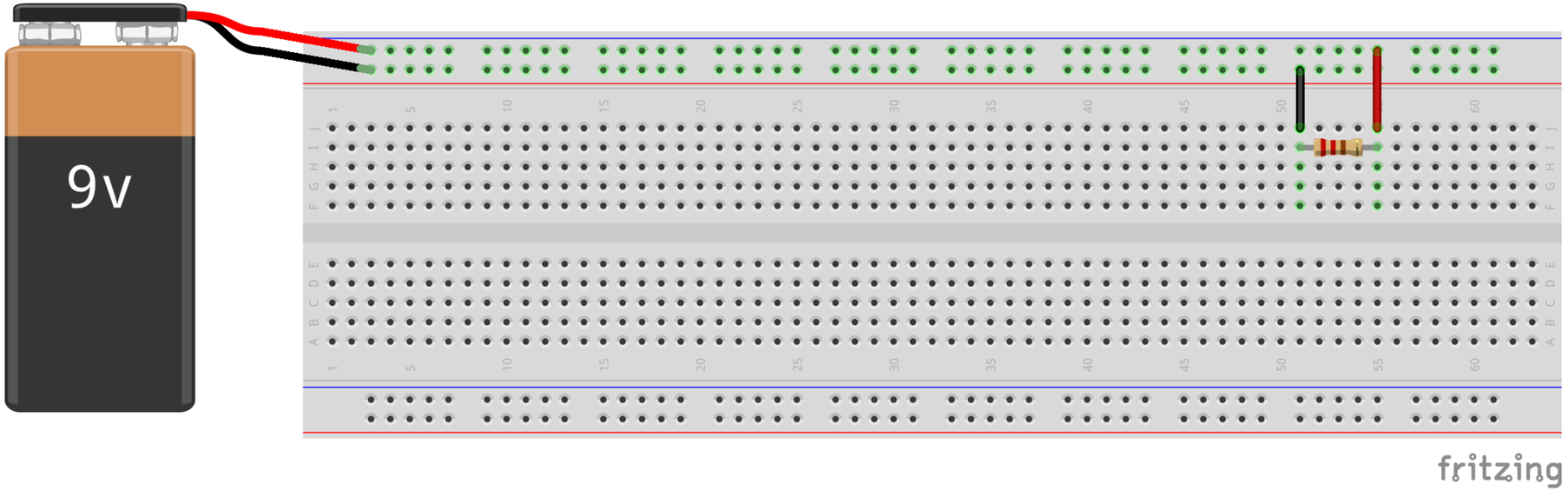

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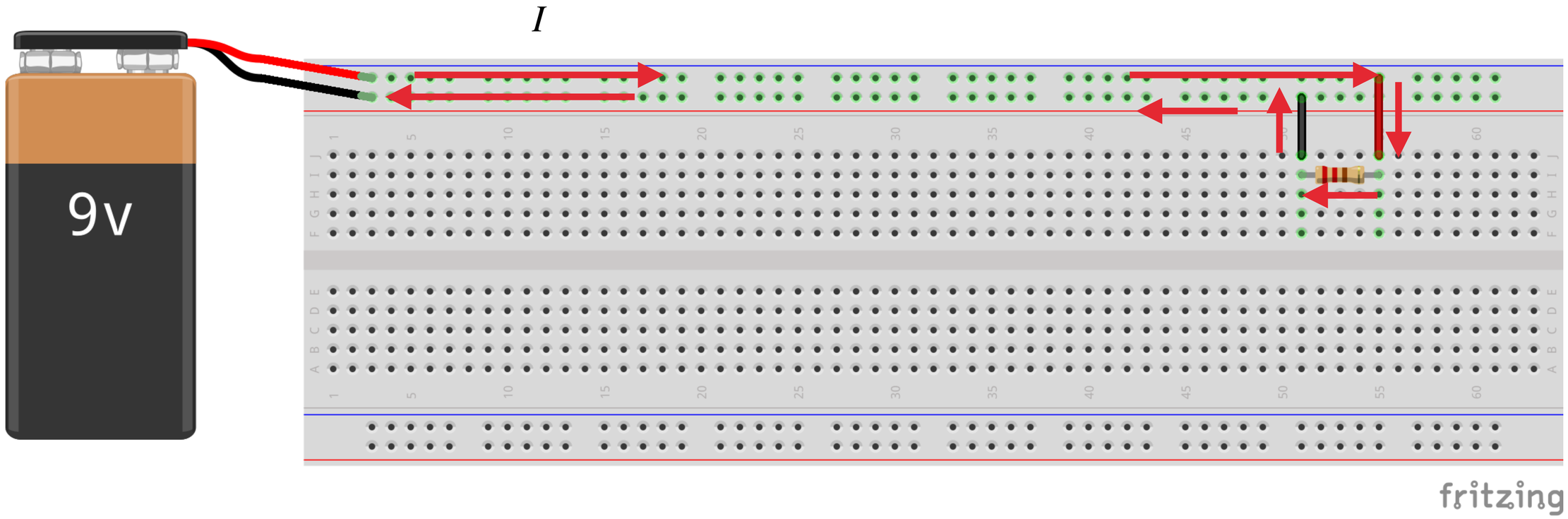

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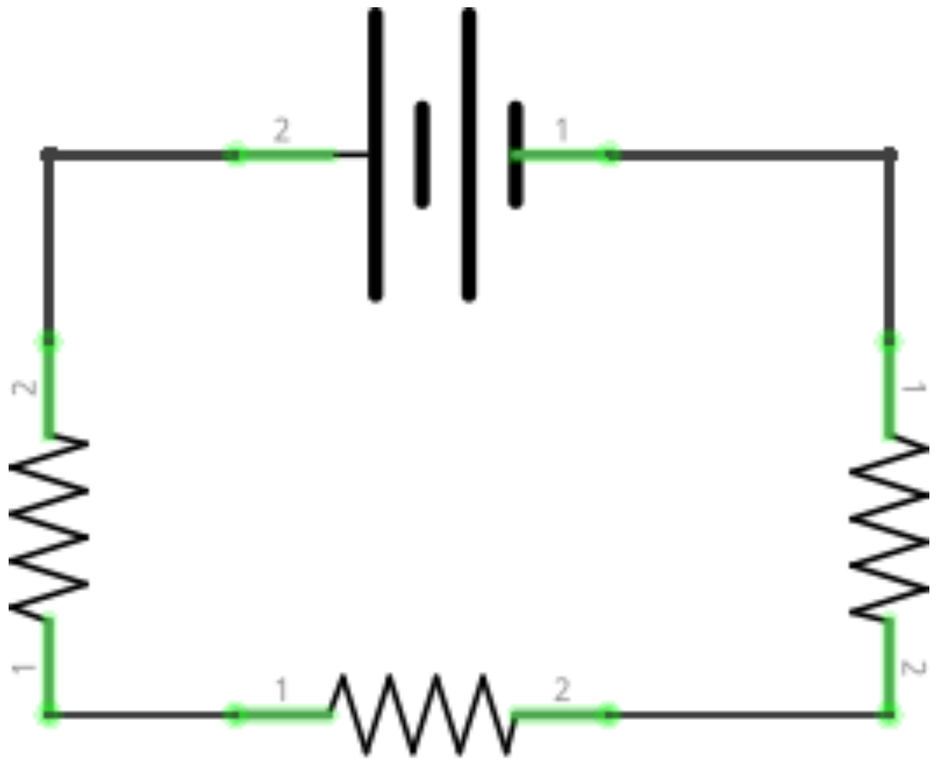

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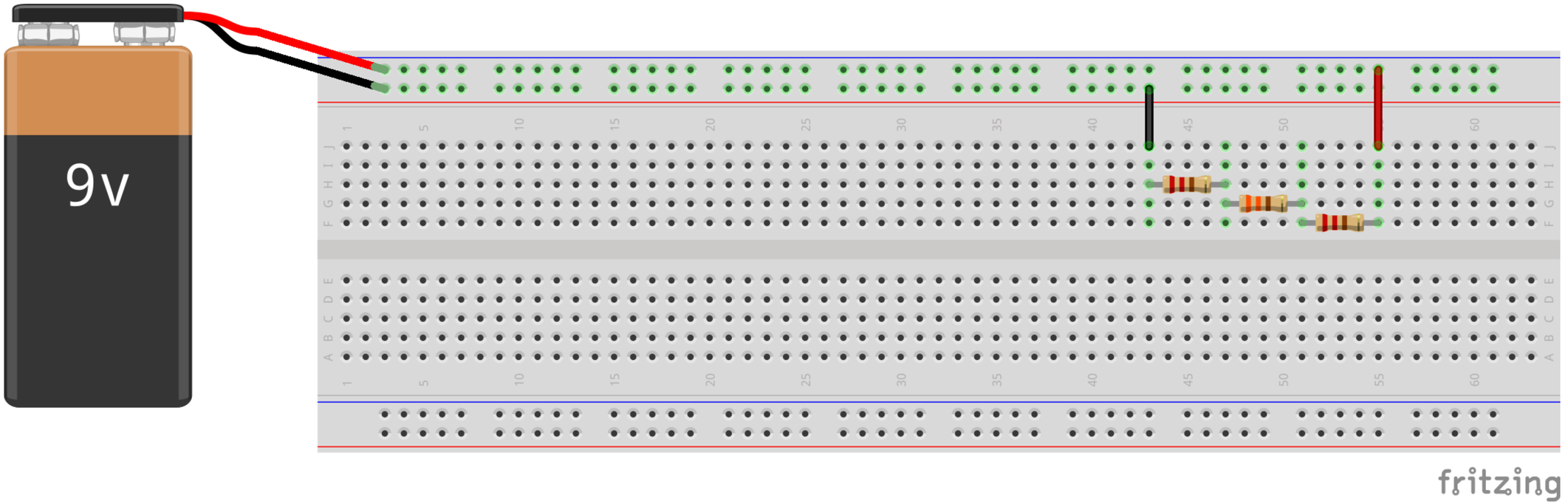

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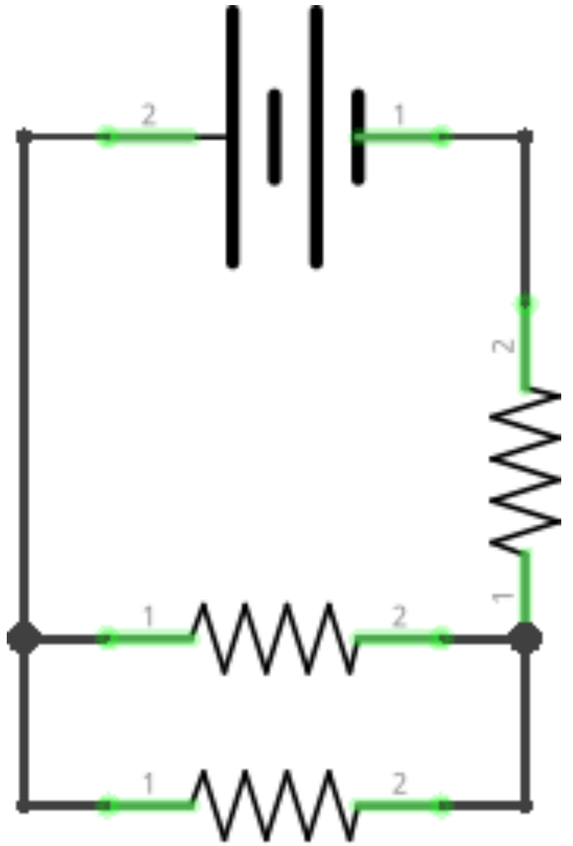

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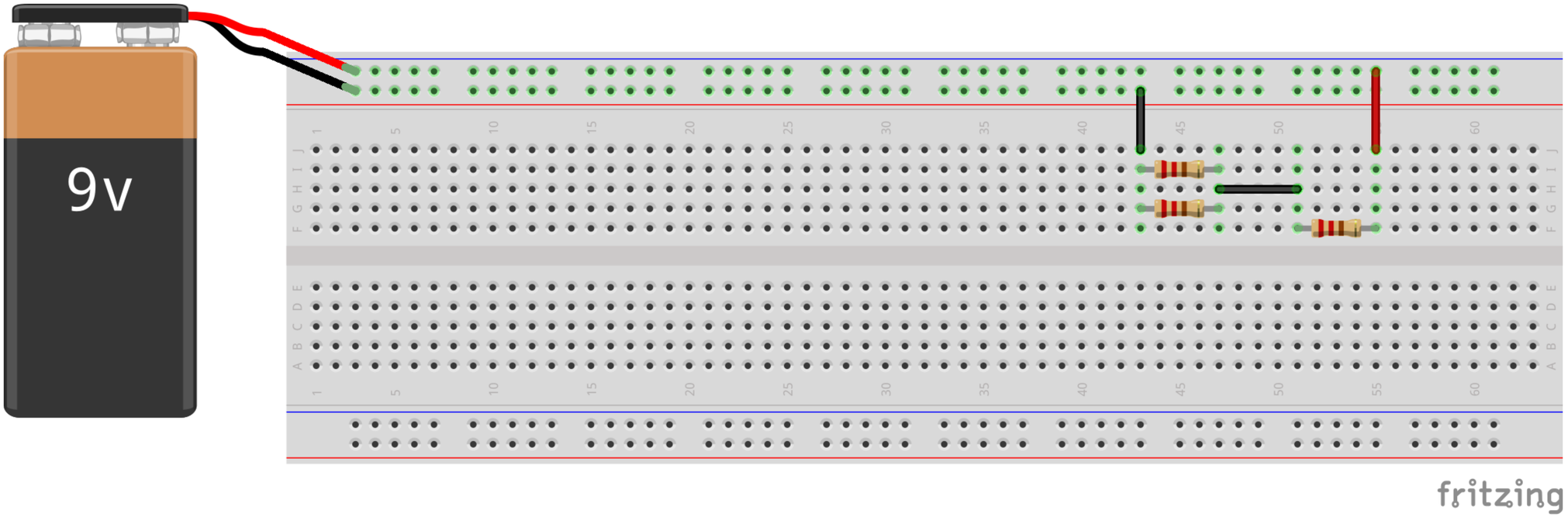
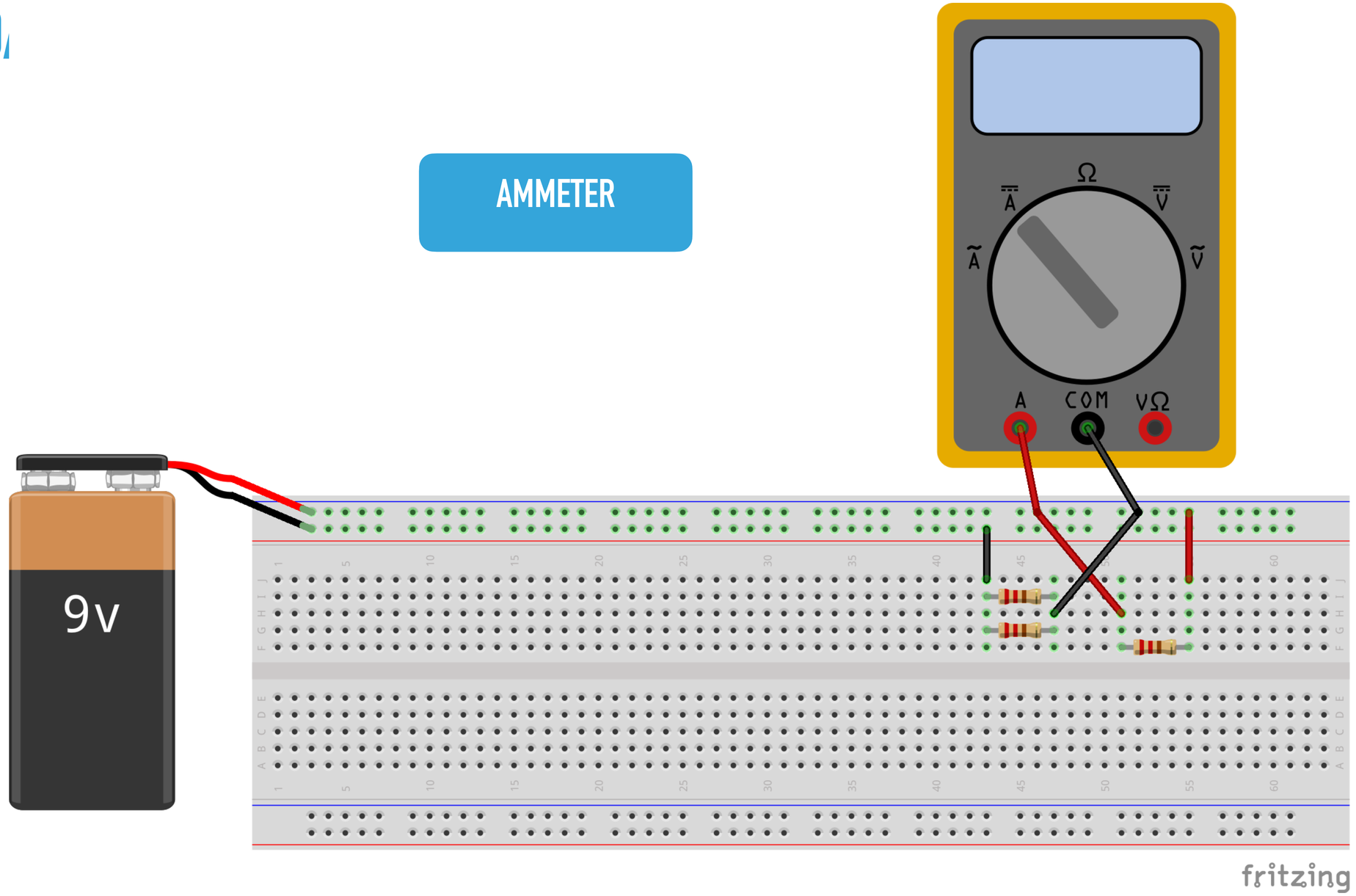


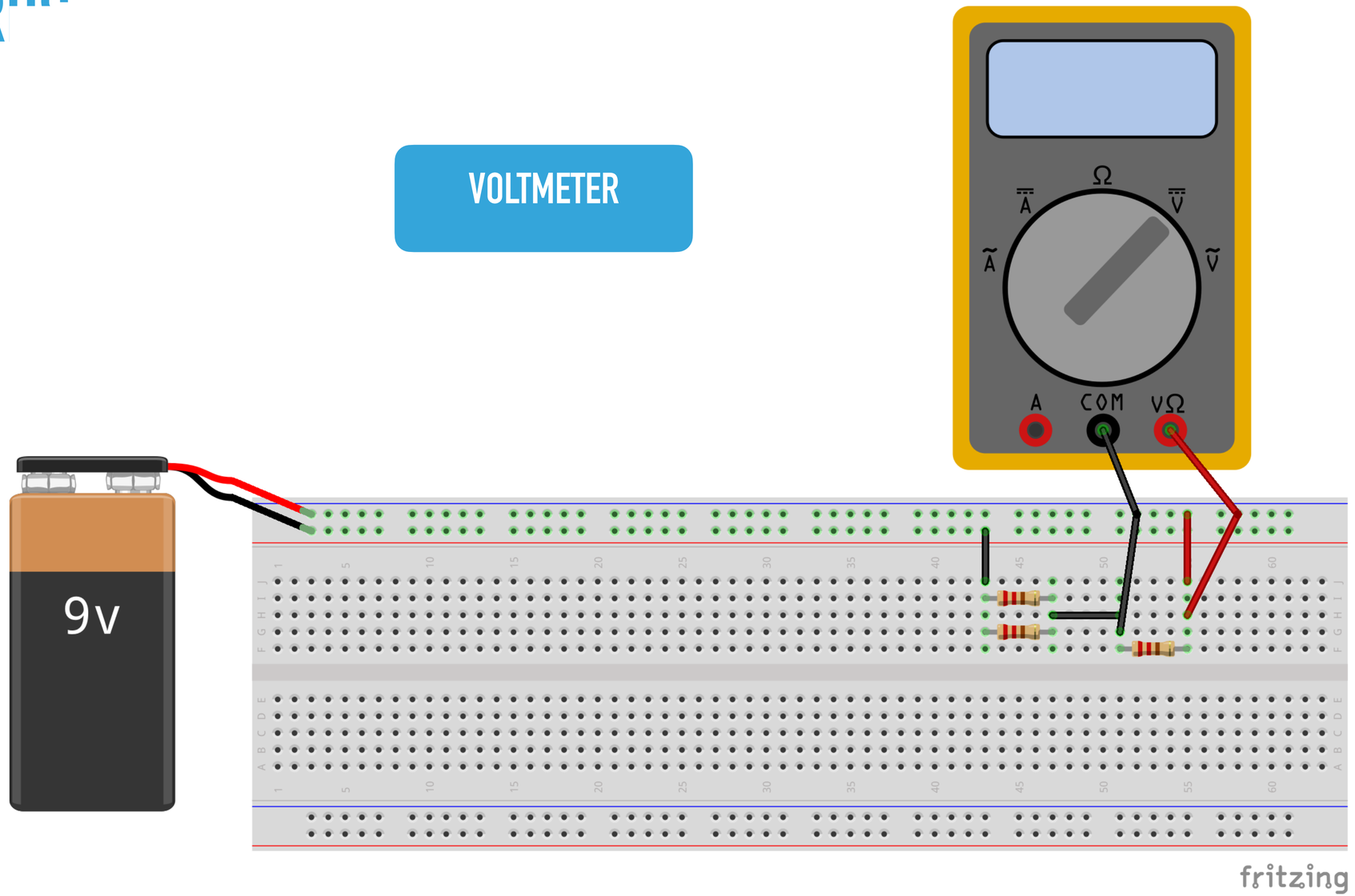
BREADBO

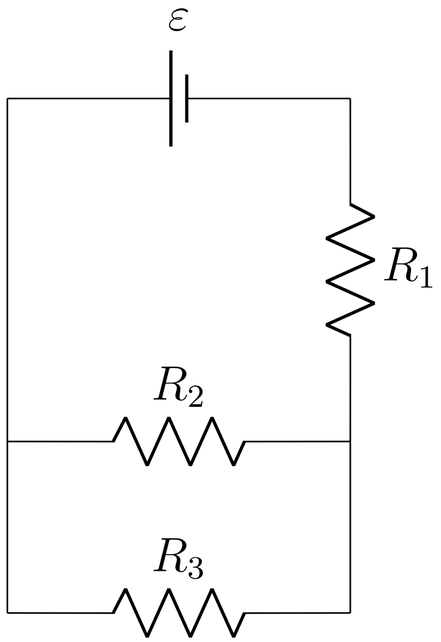
AMMETER

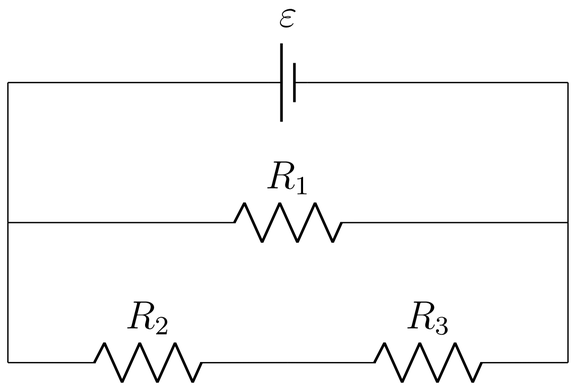


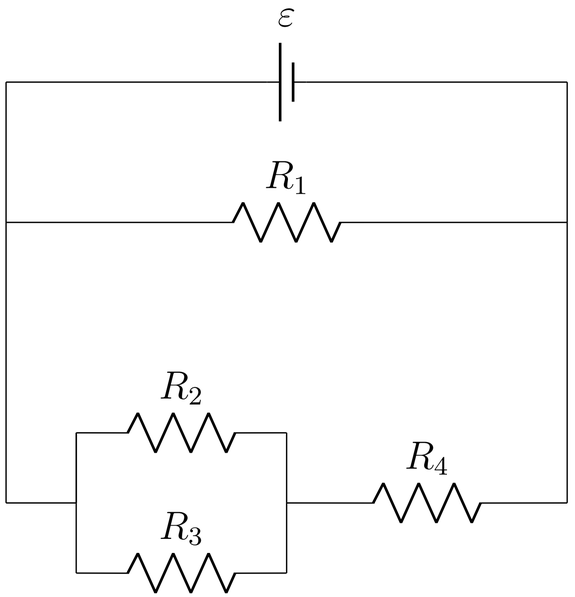
BREADBOARD

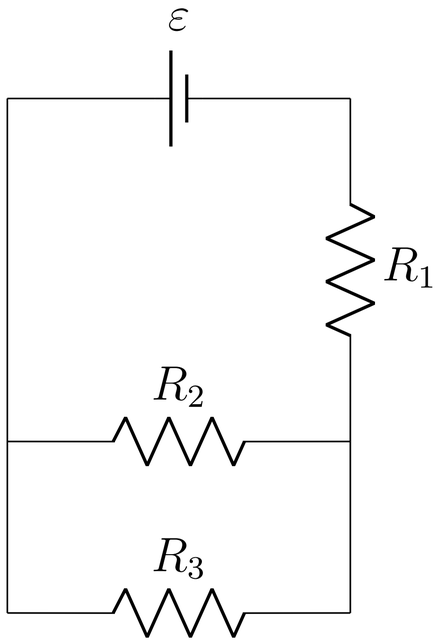
VOLTMETER

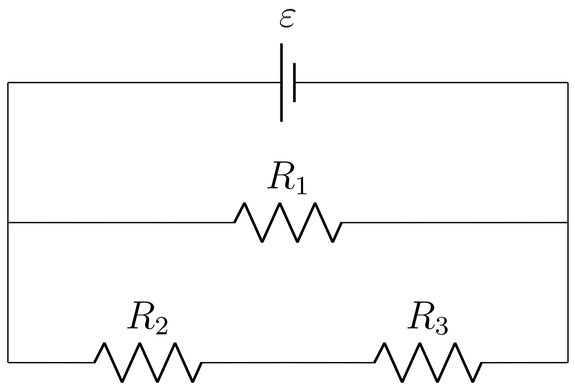


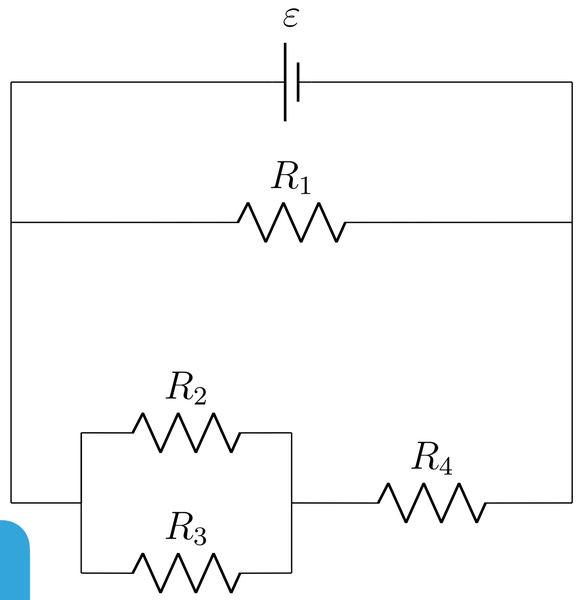

ε
R_1
R_2
R_3


ε
R_1
R_2
R_3

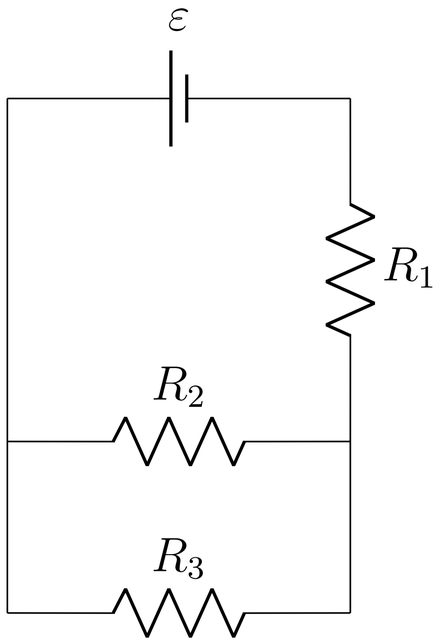

ε
R_1
R_2
R_3
R_4

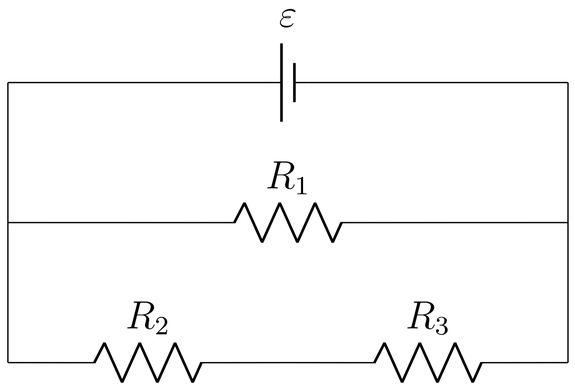


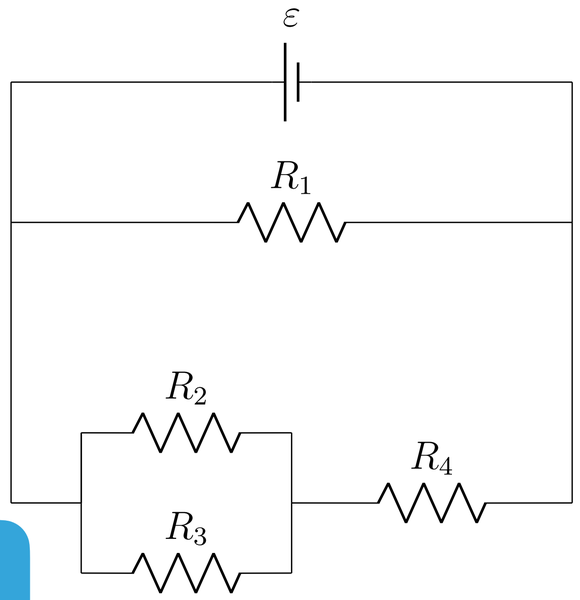




First predict, then measure, current through and voltage across *each* resistor







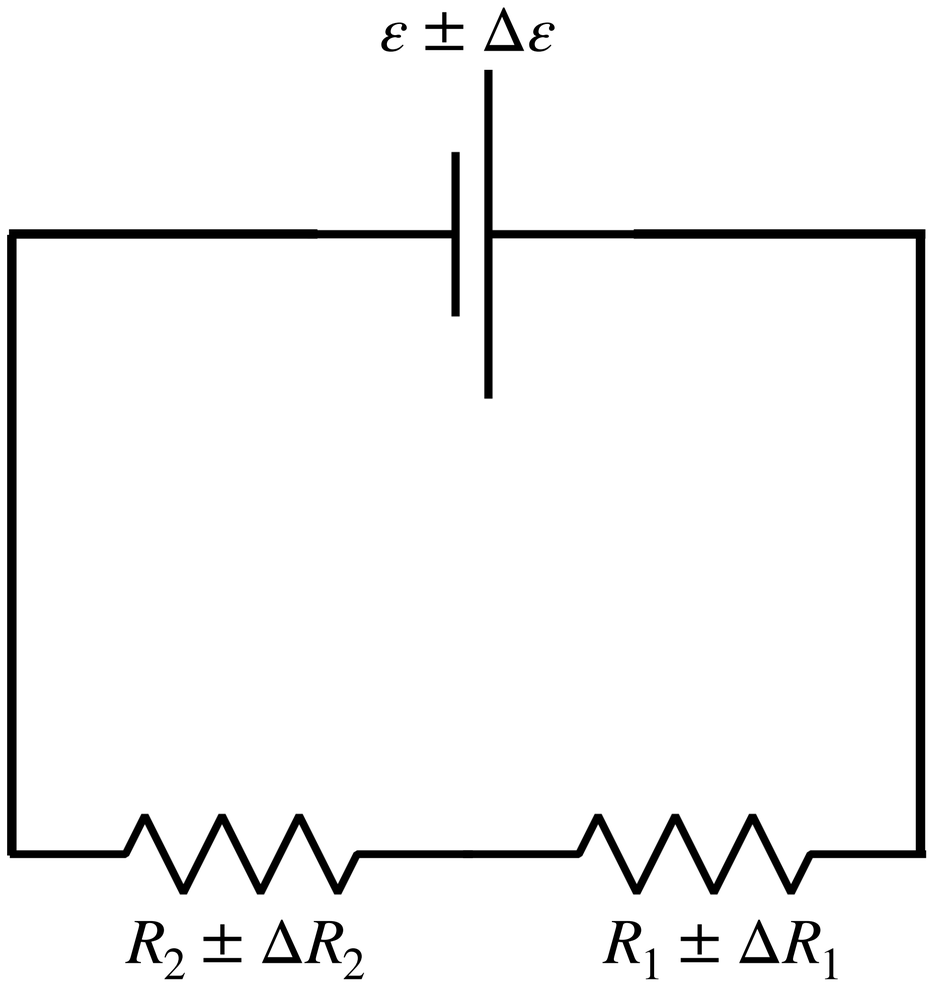
You can choose the values for your resistors

UNCERTAINTY

Uncertainty of predicted values:

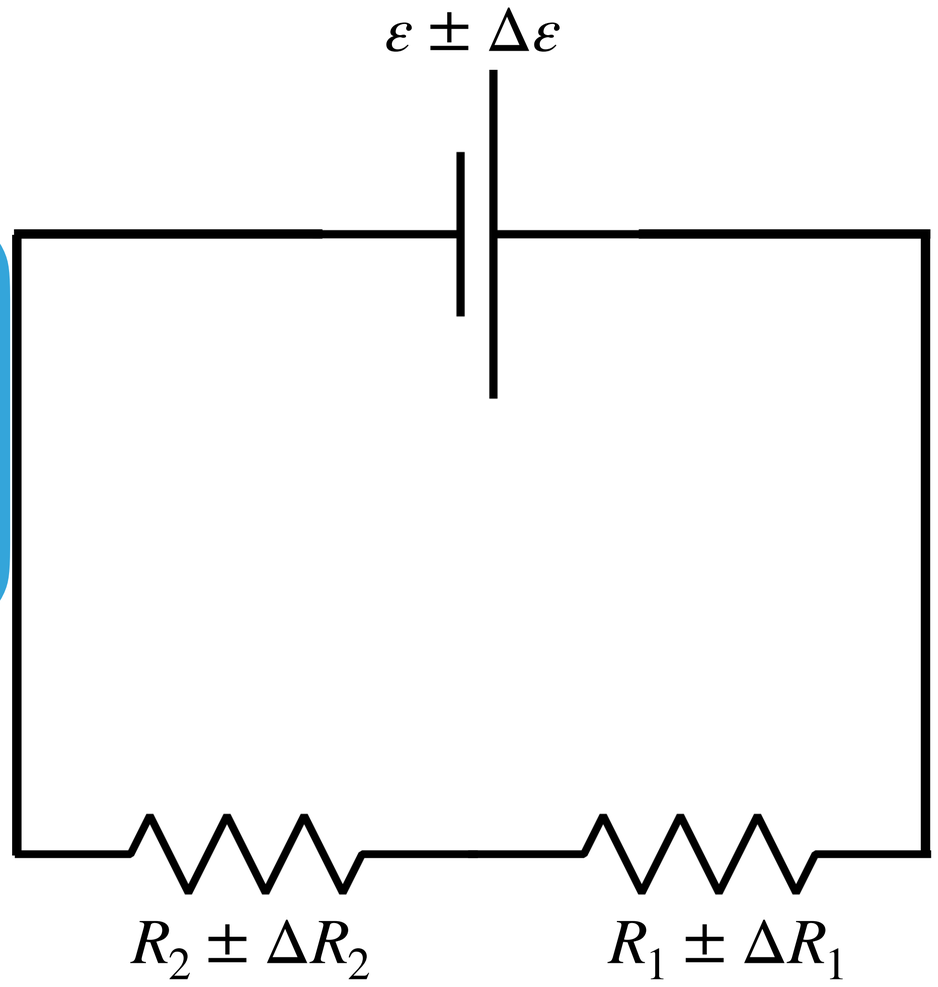
- You will measure ε and its uncertainty $\Delta\varepsilon$ (more on this in a second)
- Each resistor has a tolerance value which is the uncertainty of its resistance
- These uncertainties propagate to form the uncertainty in the predicted values of I and ΔV

EXAMPLE



EXAMPLE

If a resistor with resistance R has tolerance of 10%, then $\Delta R = 0.1 \cdot R$

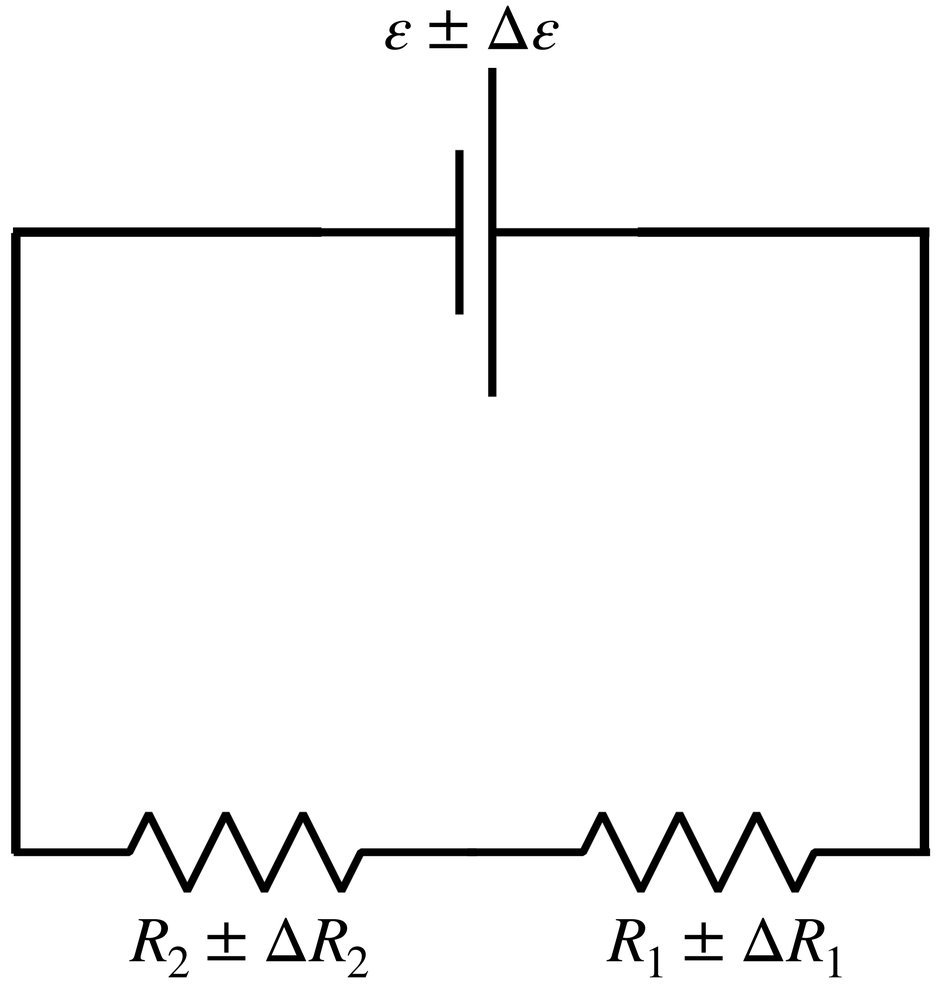


EXAMPLE

$$I_{\text{pred}} = \frac{\varepsilon}{R_1 + R_2} = \frac{\varepsilon}{R_{\text{tot}}}$$

$$R_{\text{tot}} = R_1 + R_2, \;\; \Delta R_{\text{tot}} = \sqrt{\Delta R_1^2 + \Delta R_2^2}$$

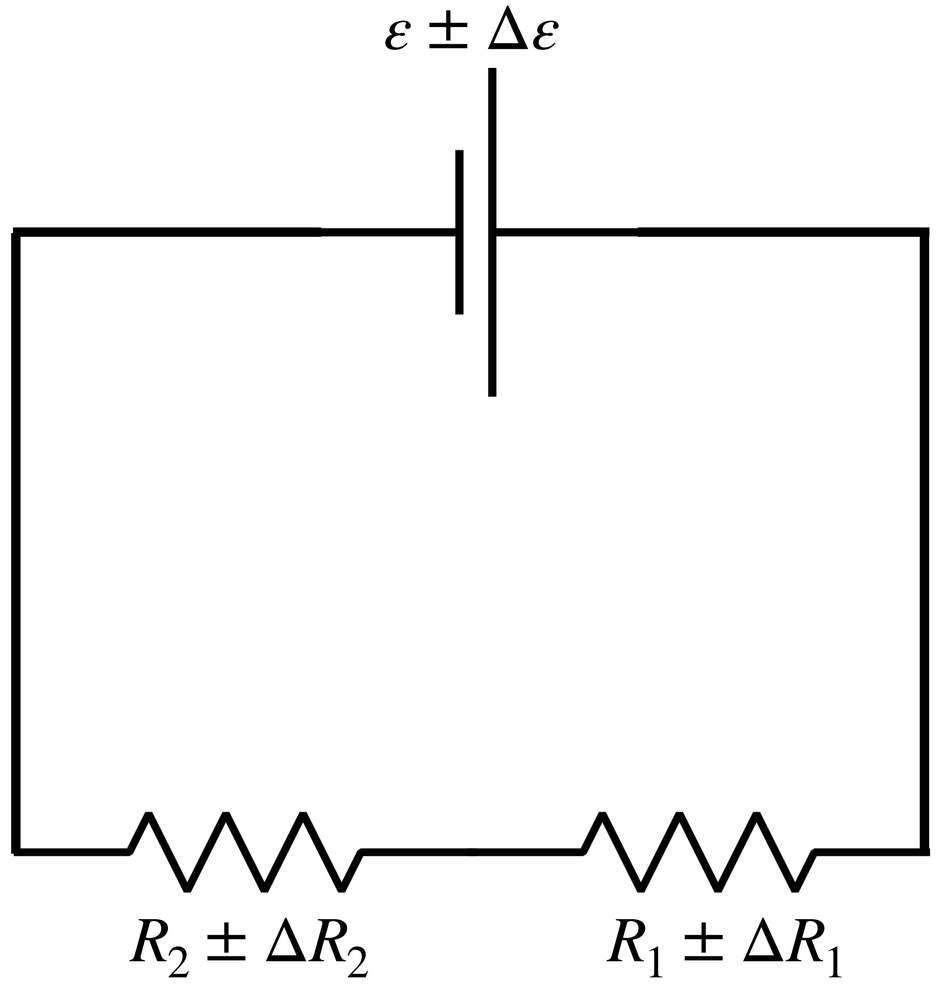
$$\Delta I_{\text{pred}} = \frac{\varepsilon}{R_{\text{tot}}} \sqrt{\left(\frac{\Delta R_{\text{tot}}}{R_{\text{tot}}}\right)^2 + \left(\frac{\Delta \varepsilon}{\varepsilon}\right)^2}$$



EXAMPLE

$$V_{1,\text{pred}} = I_{\text{pred}} \cdot R_1$$

$$\Delta V_{1,\text{pred}} = \Delta I_{\text{pred}} \cdot R_1 \sqrt{\left(\frac{\Delta I_{\text{pred}}}{I_{\text{pred}}}\right)^2 + \left(\frac{\Delta R_1}{R_1}\right)}$$



UNCERTAINTY

- Your values and uncertainties from your measured quantities are the mean and standard deviation from the multimeter

DATA TABLE FOR PART 1

				Predicted Values				Measured Values			
Circuit	Resistor #	R	R Tol.	I_{pred}	ΔI_{pred}	V_{pred}	ΔV_{pred}	I_{meas}	ΔI_{meas}	V_{meas}	ΔV_{meas}
0	1										
1	1										
	2										
	3										
2	1										
	2										
	3										
3	1										
	2										
	3										
	4										

Table 1: Data Table for Part 1

CALCULATIONS AND UNCERTAINTIES

- With several resistors, the uncertainty calculations can get a bit rough
- You will use Python's uncertainties module to help you

DETERMINING THE BATTERY PROPERTIES

- Before you begin the main part of the lab, you must determine both the **emf** and the **internal resistance** of the battery
  - You will use both of these values for your predictions later on in the lab!

DETERMINING THE BATTERY PROPERTIES

- It is up to you to devise an experiment (or set of experiments) that will enable you to determine ε, $\Delta\varepsilon$, r_{int}, and Δr_{int}
- You can make as many measurements as you like, and use any resistors you want