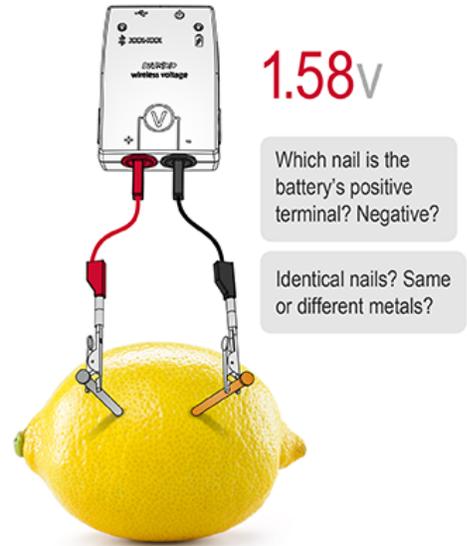


Design a lemon battery

Part 1: Design and implement a procedure for observing the effect of variables

1. Test the effect of different metals. Use a voltage sensor and the **DC_LemonBattery** experiment file, or a multimeter, to measure voltage.

- Try inserting two identical nails. Measure and record the voltage between them.
- Try two nails made from different materials. Measure and record the voltage between them. Do the materials make a difference?



2. Test the effect of distance.

- Insert two nails close to each other. Measure and record the voltage.
- Insert two nails far apart from each other. Measure and record the voltage. Does distance make a difference?
- Try to create a two-cell battery from your lemon. Try different kinds of nails and locations for the nails. What works to increase the measured voltage? Formulate a testable hypothesis and record it below.

Part 2: Design the product

- Based on what you've discovered, design a lemon battery that consists of more than one cell that will create a voltage of at least 2 V. What type of circuit do you need: series or parallel? In the space below, write down your design using a combination of text and diagrams. Make a prediction for your design's voltage and justify your prediction.

Part 3: Construct and test the prototype

- Construct the prototype of your lemon battery design using the equipment you have selected.

Part 4: Evaluate performance

- Measure and record the voltage across your prototype lemon battery.
 - Also measure and record the voltage across each individual cell in the battery.

- How well did the performance of your prototype match your prediction? Did your design exceed the performance requirement of 2 V?

Part 5: Revise the design

- Create a revised design, prototype it, and test it. If you succeed in creating a 2 V battery, then try to create even higher voltage from the materials.

Grading Rubric

Criterion	Criterion Not Met (0)	Needs Improvement (1 pt)	Satisfactory (2 pts)	Excellent (3 pts)
Testing Variables	Did not test any variables.	Tested the effect of only one variable on the voltage generated by a lemon battery.	Tested the effect of two variables on the voltage generated by a lemon battery.	Tested the effect of three or more variables on the voltage generated by a lemon battery, including the effect of adding a second cell to the battery.
Lemon Battery Prototype Design	Did not design a prototype battery.	Prototype design was missing <u>both</u> of the following: <ul style="list-style-type: none"> • a prediction with reasoning. • clear indication that the design was based on the results of the variables tested. 	Prototype design was missing <u>one</u> of the following: <ul style="list-style-type: none"> • a prediction with reasoning. • clear indication that the design was based on the results of the variables tested. 	Prototype design was complete and included a prediction with reasoning, and clear indication that the design was based on the results of the variables tested.
Prototype Performance	Did not assemble prototype battery.	Prototype battery did not produce a measurable voltage.	Prototype battery produced a measurable voltage <i>less than 2 V</i> .	Prototype battery produced a voltage <i>greater than 2 V</i> .
Revised Design Performance	Did not revise prototype design and re-assemble.	Revised prototype design, but did not evaluate revised design performance.	Revised prototype design, and <i>increased voltage production by the battery</i> .	Revised prototype design, and <i>increased voltage production by the battery by over 50%</i> .
Report Elements	Did not submit a written report.	Report was submitted but was missing some of its critical components: measurements or data were not recorded, and/or sketches or notes spaces were left blank.	Report was submitted with all critical components, but the components were incomplete or incorrect: the data were incorrect; all the questions were answered, but one or more of the answers were incorrect or unclear.	Report was submitted with all critical components: all data was presented in a coherent table or graph; all of the questions were answered with complete and correct responses, and clearly indicated understanding of the question and answer.