

Battery Lab

NAME _____

Every Friday, Bart and Lisa meet their friends at an after-school club. They spend the afternoon playing *Power Up*, a game about batteries.

The object of the game is to arrange battery cards end-to-end so that the sum of the voltages matches the target number on the spinner. A die is tossed to determine the number of battery cards that must be used. For each correct arrangement, a team earns one point.

In the last three weeks, Bart and Lisa have earned only four points, the lowest total of any team. The team with the least points at the end of the fourth week will be eliminated from the competition. Bart and Lisa need your help to avoid elimination.

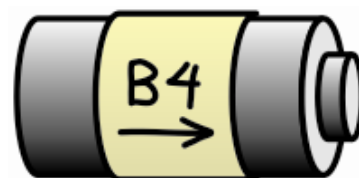
Materials

To do this lab, you will need:

- A voltage sensor
- At least 5 batteries of the same size
- Masking tape
- Ruler with ridge to hold the batteries (or a battery holder)

Set-Up

Wrap a piece of masking tape around each battery. On one side, label the batteries B1 through B5. Next to each number, draw an arrow pointing toward the positive (+) terminal.



Place Battery 1 (B1) in a battery holder or in the groove of the ruler. The positive end—and the arrow—should point to the right.

Conducting the Experiment

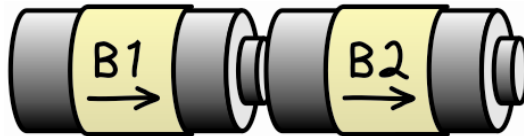
Pick up the ends of the voltage sensor, the red end in your right hand and the black end in your left hand. Place the metal tip of the red probe on the right end of the battery and the metal tip of the black probe on the left end of the battery. This creates a series circuit with the batteries and the voltage sensor.

1. Read and record the voltage for B1 in the table below.

Battery 1	Battery 2	Battery 3	Battery 4	Battery 5
B1 = ____ volts	B2 = ____ volts	B3 = ____ volts	B4 = ____ volts	B5 = ____ volts

Repeat the steps for each of batteries B2 through B5, and record their voltage in the table above.

2. Place batteries B1 and B2 into the battery holder or in the groove of the ruler. Be sure that the arrows on both batteries are pointing to the right and that the batteries are touching.



Place the metal end of the red probe on the right end of the right battery, and place the metal end of the black probe on the left end of the left battery. Read and record the **sum** of their voltages in the table below.

Sum of Voltages of B1 and B2	Sum of Voltages of B3 and B4	Sum of Voltages of B1, B2, B3, B4, and B5
B1 + B2 = _____ volts	B3 + B4 = _____ volts	B1 + B2 + B3 + B4 + B5 = _____ volts

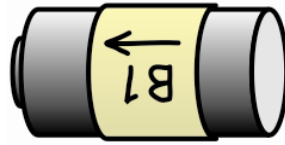
Repeat the steps using batteries B3 and B4. Then, repeat the steps using all five batteries. Be sure that the arrows of all batteries point to the right.

3. Explain how you think the voltage sensor arrived at these values.

4. Predict the following sums. Use the voltage sensor to check your answers.

B1 + B3 = _____ volts	B3 + B4 + B5 = _____ volts	B1 + B2 + B4 + B5 = _____ volts
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5. Place B1 in a battery holder or in the groove of the ruler. This time, position the battery so that the positive end is pointing *to the left*. In other words, the arrow on the battery should point to the left. Refer to this battery as Negative Battery 1, or **-B1**.



How is this value different from the value you got for B1 in Question 1?

Does this make sense? Explain why or why not.

6. Repeat the process for -B2 through -B5. Read and record the voltages in the table below.

Negative Battery 1	Negative Battery 2	Negative Battery 3	Negative Battery 4	Negative Battery 5
-B1 = ____ volts	-B2 = ____ volts	-B3 = ____ volts	-B4 = ____ volts	-B5 = ____ volts

7. Place Negative B1 and Negative B2 into the battery holder or in the groove of the ruler. Be sure that the arrows on both batteries are pointing *to the left* and that the two batteries are touching.

Place the red probe on the right end of the right battery and the black probe on the left end of the left battery. Record the sums of their voltages in the table below.

Sum of Negative B1 and Negative B2	Sum of Negative B3 and Negative B5	Sum of Negative B1, Negative B4, and Negative B5
$-B1 + -B2 = \underline{\hspace{2cm}}$ volts	$-B3 + -B5 = \underline{\hspace{2cm}}$ volts	$-B1 + -B4 + -B5 = \underline{\hspace{2cm}}$ volts

Repeat using Negative B3 and Negative B5. Then, repeat using Negative B1, Negative B4, and Negative B5. Be sure that the arrows of all the batteries are pointing to the left.

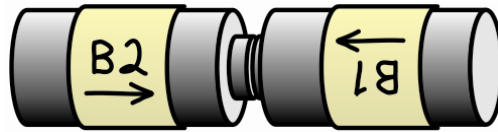
8. How do you think the voltage sensor arrived at these values? Explain.

9. Predict the following sums. Use the voltage sensor to check your answers.

$-B1 + -B3 = \underline{\hspace{2cm}}$ volts	$-B2 + -B5 = \underline{\hspace{2cm}}$ volts	$-B2 + -B3 + -B4 = \underline{\hspace{2cm}}$ volts
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Now let's take a look at batteries placed in opposite directions.

10. Place B1 and -B2 into the battery holder or in the groove of the ruler. The arrows on the batteries should face in opposite directions, and the two batteries must be touching.



Place the red probe on the right end of the right battery and the black probe on the left end of the left battery. Record the sums of their voltages in the table below.

Sum of B1 and -B2	Sum B3 and -B4	Sum -B1, B2, and -B4
$B1 + -B2 = \underline{\hspace{2cm}}$ volts	$B3 + -B4 = \underline{\hspace{2cm}}$ volts	$-B1 + B2 + -B4 = \underline{\hspace{2cm}}$ volts

Repeat using B3 and -B4. Be sure that the arrow on B3 points to the right and the arrow on B4 points to the left. Then repeat using -B1, B2, and -B5. Be sure that the arrow on B2 points to the right and the arrows on B1 and B5 point to the left.

11. Explain how you think the voltage sensor arrived at these values.

12. How did the voltage sensor determine whether the sum should be negative or positive?

13. Predict the following sums. Use the voltage sensor to check your answers.

Sum of B1 and Negative B3	Sum of B3, Negative B4 and B5	Sum of Negative B1, B2, Negative B4 and B5
$B1 + -B3 = \underline{\hspace{2cm}}$	$B3 + -B4 + B5 = \underline{\hspace{2cm}}$	$-B1 + B2 + -B4 + B5 = \underline{\hspace{2cm}}$
Sum of Negative B1 and B1	Sum of B3 and Negative B3	Sum of B1, Negative B2, Negative B1 and B2
$-B1 + B1 = \underline{\hspace{2cm}}$	$B3 + -B3 = \underline{\hspace{2cm}}$ volts	$B1 + -B2 + -B1 + B2 = \underline{\hspace{2cm}}$

14. Write a DESCRIPTION and the PURPOSE of this lab.

15. List all MATHEMATICAL OBSERVATIONS. When adding positive and negative integers...

- a. If both of the signs are **positive** (all arrows point to the right), you _____ the numbers and the sign of the answer is _____.
- b. If both of the signs are **negative** (all arrows point to the left), you _____ the numbers and the sign of your answer is _____.
- c. If the signs of the two numbers are **different** (arrows point in opposite directions), you ignore the signs and _____ the numbers. The sign of your answer is determined by _____.

16. What advice would you give Bart and Lisa about playing the *Power Up* game?

17. Using what you learned in this lab, determine the following sums.

- a. $-8 + -3 =$ _____
- e. $-4 + -6 =$ _____
- i. $-15 + 7 + 15 =$ _____
- b. $6 + -6 =$ _____
- f. $18 + -17 =$ _____
- j. $0 + -11 =$ _____
- c. $-12 + -17 =$ _____
- g. $-8 + 8 + -11 =$ _____
- k. $6 + -5 + -4 =$ _____
- d. $9 + -11 =$ _____
- h. $12 + -7 + 3 + -8 =$ _____
- l. $-5 + -16 + 5 + 16 =$ _____