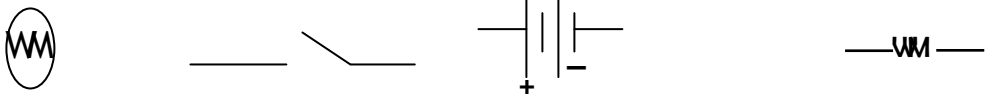
Batteries & Bulbs

Simple Circuits

An electric circuit is a complete conducting path for an electric current. When the circuit is connected to a battery, electrons flow from the negative terminal of the battery, through one or more electrical devices, and then back to the positive terminal of the battery. There are different ways in which circuits can be wired, and these ways can be described with words or by symbols that are widely known and used. Some of these symbols are illustrated below.



Bulb | ***Open Circuit*** | **Battery with 2 cells** | **Resistor**

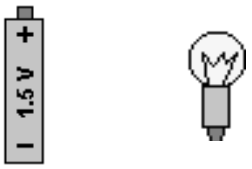
The battery pack supplied consists of 4 - 1.5 volt (V) cells connected one after the other. Connecting any electrical device one after the other is called a ***"series circuit".*** Placing the batteries in series results in the voltages of the batteries to be added, thus the total voltage of the four cells is 6.0 V.

The **current** which flows through the circuit depends upon the number of electrons flowing through the circuit per second. When using batteries, increasing the voltage also increases the current in the circuit. An increase in the current is observed when the brightness of the bulb increases. If any series bulb is unscrewed, an open circuit is created and no current exists.

Each device placed within the circuit provides a **resistance** to the electrons flowing through the wire. Some devices apply greater resistance than others. As the number of devices placed within one series circuit increases, the resistance also increases. In a parallel circuit, as electrical devices are added the resistance decreases.

I. Making the Connection

Use one cell, one bulb (no base), and one piece of connecting wire (called an electrical lead) make the bulb light. Using the diagrams of the cell and bulb (illustrated to the right), sketch your orientations below. There are four possible orientations of the cell and battery that make the bulb light.



1	2	3	4

II. Placing Cells in Series

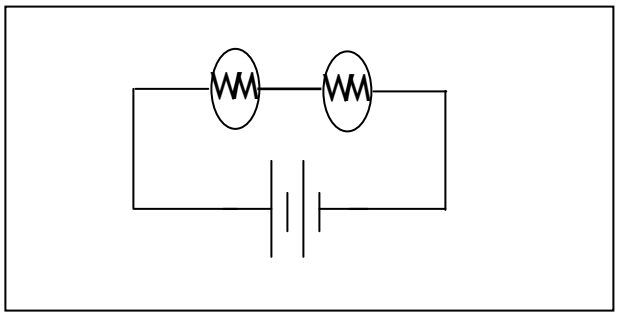
Using the 4-cell battery pack, orient the metal terminals so that only one cell is connected. Using two pieces of electrical leads, connect one bulb (with base) to the battery to make it light. Using the symbols (illustrated on the top of the first page) for the battery (two cells) and bulb, draw a diagram of this circuit in the box to the right. Indicate the path of the electrons.

Increase the number of cells in series used to light the bulb and record your observations concerning the brightness of the bulb when the number of cells (voltage) in the circuit increases.

Placing cells in series increases the voltage in the circuit by 1.5 V for each cell. Increasing the voltage increases the brightness of the bulb.

III. Placing Bulbs in Series

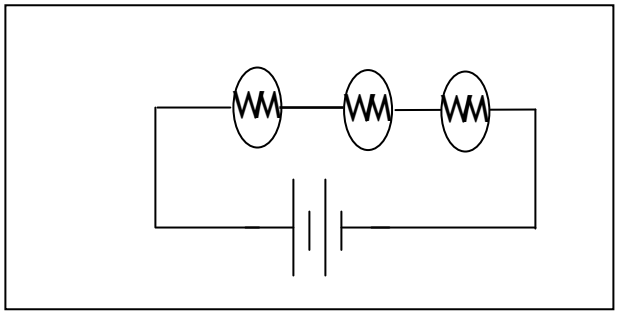
Place **two** bulbs in series by connecting the two bulbs with an additional electrical lead between the bulbs. Start with one cell and record the brightness of the bulbs. Increase the number of cells in the circuit and record your observations as the voltage in the circuit increases. Unscrew one of the bulbs and record your observations. A circuit diagram of two cells and two bulbs in series is shown below



When a bulb in a series circuit is unscrewed all bulbs in the circuit go out.

Place **three** bulbs in the circuit by connecting the bulb with another electrical lead. Unscrew one of the bulbs and record your observations. Vary the voltage within the circuit and record your observations. Sketch a diagram of the circuit.

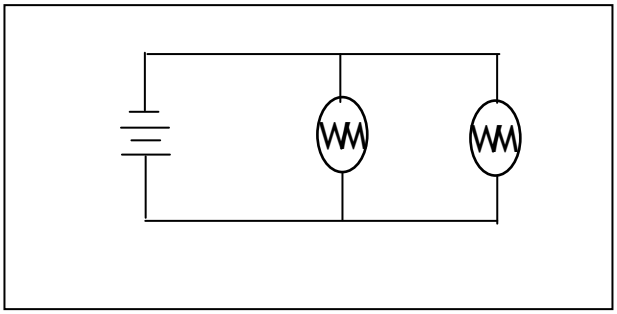
Increasing the number of bulbs in a series circuit decreases the brightness of the bulbs. In a series circuit, the voltage is equally distributed among all of the bulbs.



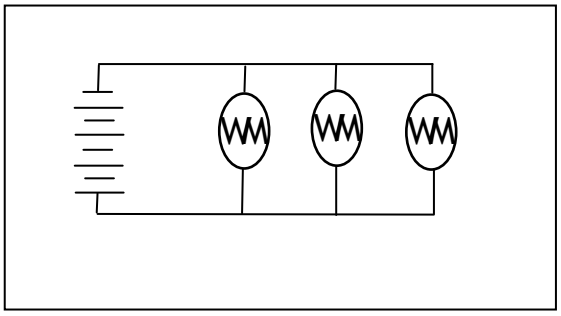
IV. Bulbs Placed in Parallel

Using two cells, two bulbs, and four electrical leads, connect the two bulbs in parallel as shown in the diagram. Note the brightness of the bulbs and compare this brightness with the two bulbs connected in series. Unscrew one the of the bulbs and record your observations. Sketch a diagram of this circuit diagram.

Bulbs in parallel are brighter than bulbs in series. In a parallel circuit the voltage for each bulb is the same as the voltage in the circuit. Unscrewing one bulb has no effect on the other bulb.



Using four cells and three bulbs, and two additional electrical leads, connect three bulbs in parallel. Note the brightness of the bulbs and compare this brightness with three bulbs connected in series. Unscrew one of the bulbs and record your observations. Sketch a diagram of the circuit.



Bulbs in parallel are brighter than bulbs in series. Unscrewing a bulb does not affect the other bulbs.

V. Cells Placed in Parallel

Using two cells, two long aluminum strips, and two rubber bands, connect the two cells in parallel so that the two positive terminals are connected together and the two negative terminals are connected together. Connect a light bulb to the battery using two leads. Compare the brightness of the bulb produced by two cells in parallel with two cells in series.

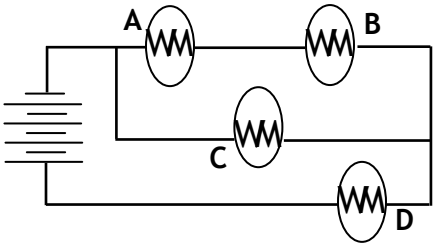
A bulb connected to two cells in series is brighter than connected two to cells in parallel.

Compare the brightness of the bulb produced by two cells in parallel with one cell.

A bulb connected by two cells in parallel is equally bright as when connected to one cell. In both cases the voltage is 1.5 V. Two cells in parallel will last twice as long as a single cell. Two cells in series produce a brighter bulb, but will last as long as a single cell.

VI: Circuits With Series and Parallel Bulbs Together

Construct a circuit using the diagram shown below. Record your observations of the brightness for each of the bulbs in the circuit. Unscrew each bulb, one at a time, to see how the circuit is affected. Answer the questions concerning this circuit which appear in the postlab section of this laboratory handout.



Observations

Bulb D is the brightest. Bulbs A and B are the dimmest, and equally bright. Bulb C has a brightness between bulb D and bulbs A & B.

VII: Problem Solving With Circuits

Construct one circuit and draw a **single circuit diagram** for a circuit which contains three bulbs which meet **all** of the following criteria:

1. When all bulbs are lit, bulb A is the brightest and bulbs B and C are equally bright.
2. If you unscrew A, bulbs B and C remain the same.
3. If you unscrew B, A remains the same and C goes out.
4. If you unscrew C, A remains the same and B goes out.
5. If you unscrew B and C, A remains the same.

Postlab Questions:

I. Making the Connection

How many terminals are located on the battery? **2**

How many terminals are located on the bulb? **2**

II. Placing Cells in Series

What is the effect on the brightness of the bulb by increasing the number of cells?

The bulbs become brighter when increasing the number of cells.

What changes occur in the current in the circuit when increasing the number of cells?

Increasing the number of cells increases the current in the circuit.

What changes occur in the voltage in the circuit when increasing the number of cells?

Increasing the number of cells increases the voltage (for cells in series the voltage is additive).

What changes occur in the resistance in the circuit when increasing the number of cells?

The resistance is determined by the number of bulbs. The resistance in the circuit remains unchanged.

III. Placing Bulbs in Series

What is the effect on the brightness of the bulbs by increasing the number of bulbs?

Increasing the number of bulbs decreases the brightness of the bulbs.

What changes occur in the resistance in the circuit as more bulbs are added?

The resistance increases. In a series circuit, adding bulbs increases the resistance in the circuit.

What changes occur in the current in the circuit as more bulbs are added?

Increasing the resistance decreases the current.

Observations on unscrewing one bulb. Explain your observations.

A complete circuit requires the electrons to move from the negative terminal of the battery to the positive terminal. When one bulb is unscrewed it opens the circuit preventing a complete circuit and the electrons cannot return to the battery.

IV. Placing Bulbs in Parallel

Compare the brightness with two bulbs in parallel with two bulbs in series.

Two bulbs in parallel are brighter than two bulbs in series.

How does increasing the number of circuits (bulbs) change the current and resistance?

In a parallel circuit each bulb is in its own circuit. As bulbs are added the resistance in the circuit decreases since each circuit is another pathway for electrons to move from one end of the circuit to the other.

V. Cells Placed in Parallel

To get the most light from two cells and two bulbs you would connect the cells in **series** and the bulbs in **parallel**.

To get the least light from two cells and two bulbs you would connect the cells in **parallel** and the bulbs in **series**.

To get the longest life time from two cells and two bulbs you would connect the cells in **parallel** and the bulbs in **series**.

VI. Circuits with Bulbs Placed in Series and Parallel Together

Which bulb is (or bulbs are) the brightest in the circuit? Explain your reasoning.

Bulb D. It appears in two circuits.

What happens to the brightness of bulb A if bulb B is unscrewed? Explain.

It goes out since bulb A is in series with bulb B.

What happens to the brightness of bulb D if bulb B is unscrewed? Explain.

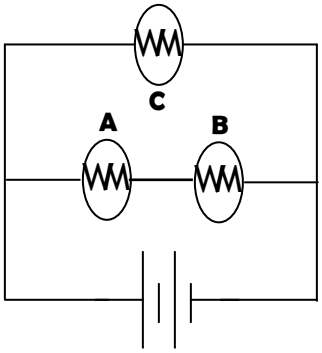
It becomes dimmer. Unscrewing B opens that circuit, thus bulb D is in only one circuit (with bulb C).

What happens to the brightness of bulb C if B is unscrewed? Explain.

Goes out. Bulb D is in series with bulb C.

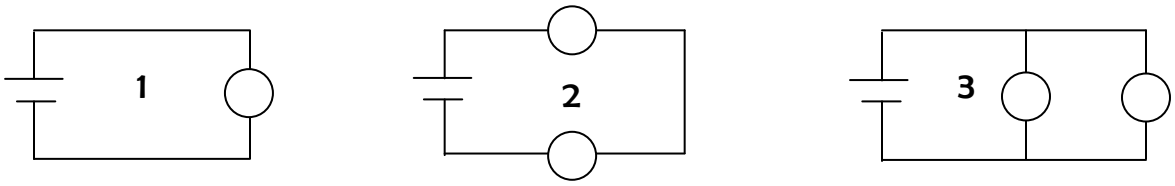
VII. Problem Solving With Circuits

Draw a circuit diagram which meets the conditions stated.



PROBLEM SET: BATTERIES & BULBS

Use the following diagrams to answer questions 1 and 2.



1. Looking at circuit 2...
   a. How will the brightness of the bulbs compare to each other?

      The bulbs in circuit 2 are equally bright.

   b. How will the brightness of the bulbs in circuit 2 compare to the bulb in circuit 1?

      Dimmer since they are in series.

2. Looking at circuit 3...
   a. How will the brightness of the bulbs in circuit 3 compare to each other?

      The bulbs in circuit 3 are equally bright.

   b. How will the brightness of the bulbs in circuit 3 compare to the bulb in circuit 1?

      About equally bright.

   c. How will the brightness of the bulbs in circuit 3 compare to the bulbs in circuit 2?

      Brighter since they are in parallel.

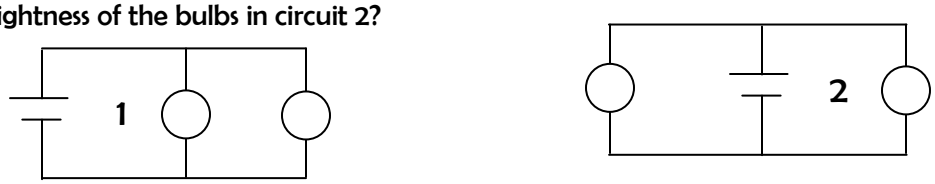
3. If one of the bulbs were unscrewed from the light socket that connects it to the circuit...
   a. ...what will happen to the brightness of the other bulb in circuit 2?

      Both bulbs go out.

   b. ...what will happen to the brightness of the other bulb in circuit 3?

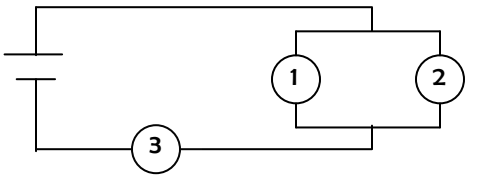
      One bulb will remain lit.

4. Looking at the following circuits, how will the brightness of the bulbs in circuit 1 compare to the brightness of the bulbs in circuit 2?

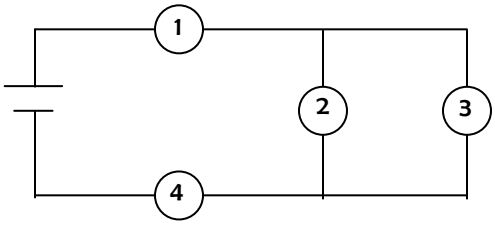


Both circuits are equal since they are parallel circuits.

5. For the following circuits, rank the bulbs from brightest to dimmest.

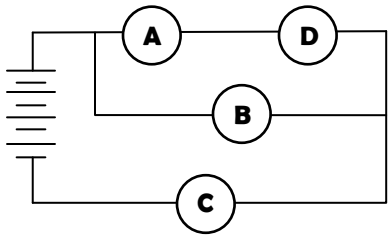


3 – brightest, 1 equal in brightness to 2



1 & 4 are brightest, 2 is equal in brightness to 3

6. Draw a circuit diagram that meets all of the following requirements:
    1. When all bulbs are lit, C is the brightest and bulbs A and D are the dimmest.
    2. If C is unscrewed, all bulbs go out.
    3. If B is unscrewed, bulbs A, C and D are equally bright.
    4. If A is unscrewed, bulb D goes out and bulb C becomes dimmer.



7. Provide a rationale for each of the above criteria, that is, explain in terms of **current, resistance, series and parallel** circuits why the above criteria occur:

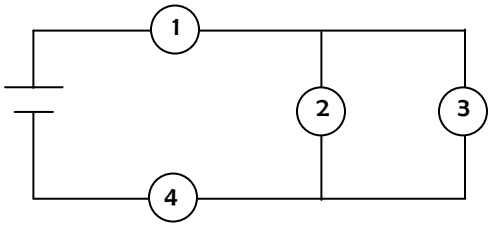
1. **Bulb C is in parallel with A and D and in series with B. Two bulbs in series have a lower resistance than three bulbs in series.**

2. **Bulb C is in series with all bulbs. Unscrewing C opens both circuits making all bulbs go out.**

3. **Bulb B is in series with C. When unscrewed it opens the circuit and C remains in a series circuit with A and D. Three bulbs in series are equally bright.**

4. **Bulb A is in series with D. When unscrewed it opens the circuit and D goes out. The remaining circuit contains bulbs B and C. C dims because it is in only one circuit.**

8. Answer the following questions using the circuit diagram below.



a. What happens to the brightness of bulb 2 when bulb 3 is unscrewed? **Remains the same.**

b. What happens to the brightness of bulb 4 when 1 is unscrewed? **Goes out.**

c. What happens to the brightness of bulb 4 when 2 is unscrewed? **Becomes dimmer.**