



Universiti Teknologi MARA
Fakulti Sains Gunaan

Batteries and Bulbs: Voltage, Current and Resistance

PHY407: A Physical Science Activity

Name: _____ HP: _____ Lab # 5:

Objective:

Today's activity explores and investigates properties such as current, potential drop and the brightness of light bulbs when batteries or bulbs are connected in series and parallel.

At the end of the activity, students will be able to:

- Use a multimeter to determine the electromotive force of dry cells connected in series and in parallel.
- Connect a simple direct current (DC) circuit and light up a light bulb using a dry cell, wires and a switch.
- Connect a multimeter or an ammeter in a circuit and measure current for a series and for a parallel circuit.
- Connect a more complex circuit, identify and relate brightness of bulbs, current and potential drops when bulbs are connected in series.
- Identify and relate brightness of bulbs, current and potential drops when bulbs are connected in parallel.
- Obtain, explain and describe the relationship between bulb intensity, current, voltage resistance and power in a series and in a parallel circuit.

Background Information

Background:

Conductors are materials that allow excess electrons to move easily within the material when subjected to an electric field. The existence of electric field is then associated with electrical potential energy and hence potential difference which is the ratio of the work done on a test charge (in bringing the charge from one point in space to another) to the magnitude of the test charge. Charges which move, do so in the presence of electric field or due to potential difference or voltage between points in a material. The charges can come from many sources but the most common source is the battery. A battery is the source of electromotive force (EMF), a maximum voltage between the terminals of a battery. This emf is the main agent to cause charge to move in a circuit.

When charges move or flow in a circuit, the rate of its flow is called electric current. Hence the current I , is the amount of charge in Coulomb, that pass through an imaginary surface in one second. The average current is $I = \frac{\Delta q}{\Delta t}$, measured in units of Ampere (A). So, one ampere represents the flow of one coulomb of charge (can you determine the number of electrons involved?) through a conductor within a period of one second. Another common unit is the milliampere (mA) or 10^{-3} A. In a circuit, the direction of current flow is chosen to be the opposite of the electron flow. Hence, since the negative terminal of a battery is negatively charged (negative potential) compared to the positive terminal, then current will flow beginning from the positive terminal of a battery and ending at the negative terminal of

the battery if there are conducting wires between the terminals. Often, a load or a resistor is placed between the terminals. If the resistor is a bulb, the bulb may light up when current flows through it. The strength to resist the flow of current in a resistor is called resistance, R , measured in units of Ohms (Ω) and its value depends only on the geometry of the resistor itself such as the type of conductor (element), its length and its surface area. Resistors or devices which have a linear relationship between voltage and current obey Ohm's Law.

Current in a circuit can be measured by using an ammeter which must be connected by breaking up a point in the circuit. This type of connection is usually referred to as a series connection. In addition, since charges (electrons) move between points in a circuit under the influence of the battery's emf, then potential difference exist between points in the circuit. This potential difference, (measured in volts (V)), can be measured by using a voltmeter and is done by touching the probes of the voltmeter across the points of interest in the circuit. This type of connection is referred to as parallel connection. Light bulbs in a circuit light up with different brightness depending on the average power it consumes. For any device, its average power is the product of the current through it and the voltage across it, $P = IV$. The higher the intensity (brightness) of a bulb, the higher is the average power.

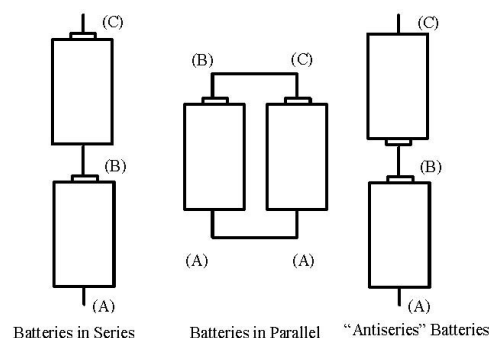
Student Activity

Investigation 1-Lighting a Bulb

(DO YOUR PREDICTION BEFORE STARTING THE ACTIVITIES)

Prediction 1.1: (Batteries shown in the figure below are each 1.5 V battery)

- What will the voltmeter reading be if the probes are connected between points A and B? Will it change if the probe of the voltmeter is reversed?
- Would the reading change if the probes are placed between points B and C, and between A and C?
- What would the reading be if the positive terminals are connected together in an antiseriess connection



Activity 1.1: (You MUST run the PhET (Circuit Construction Kit (DC only)) simulation first before attempting to do the following activities in the lab. Set the battery voltage to 1.5 V)

Observe the batteries and identify the positive and negative terminal. Using a multimeter with the dial set at DC, place the probes at points A and B respectively for each of the case above and record the reading. You may need to change the dial on the meter to get the best reading.

Repeat the above for points B and C and points A and C. Then reverse the probes starting with points B and A, C and B, and C and A. Record you reading and tabulate the data.

PhET Points	V, volts Series	V, volts Parallel	V, volts Antiseries	Points reversed	V, volts Series	V, volts Parallel	V, volts Antiseries
V_{AB}				V_{BA}			
V_{BC}				V_{CB}			
V_{AC}				V_{CA}			

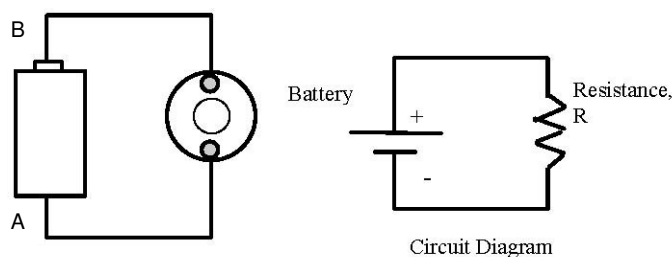
Points Lab	V, volts Series	V, volts Parallel	V, volts Antiseries	Points reversed	V, volts Series	V, volts Parallel	V, volts Antiseries
V_{AB}				V_{BA}			
V_{BC}				V_{CB}			
V_{AC}				V_{CA}			

Questions

1. What happens to the voltage when batteries are connected in series, in parallel and in antiseries respectively?

Prediction 1.2: (The battery shown in the figure below has an emf of 6 V.)

- i) Will the bulb in the figure light up if the polarity is reversed?
- ii) What happens when the bulb in the figure below is unscrewed a bit?
- iii) Do you think that the potential difference across the terminals of the bulb is the same as across the terminals of the battery?



- iv) What happens to the brightness of the first bulb when another bulb is added in series? How will the brightness change if the third bulb is added?
- v) What happens to the current in the circuit for the case in part (iv)?
- vi) What happens to the voltage across the bulbs for the case in part (iv)?

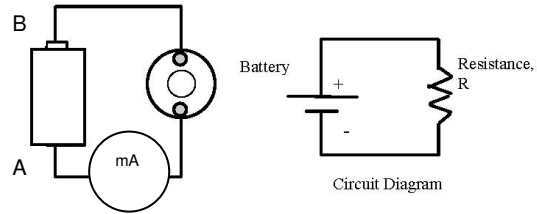
Activity 1.2: (You MUST run the PhET (Circuit Construction Kit (DC only)) simulation (use the lifelike mode) first before attempting to do the following activities in the lab. Set the battery voltage to 6 V and the resistance for each bulb at 5.0 Ω)

- i) Using the battery holder, the bulb and 2 wires, wire up the simple circuit above. It is best for you to also have a switch in the circuit. Observe what happens to the bulb when the switch is thrown down, when the bulb is unscrewed a little and when the battery terminals are reversed. Write down your observation.

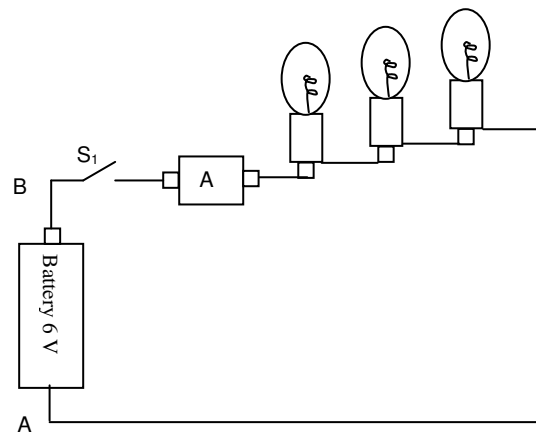
- ii) Using a multimeter, record the potential difference (voltage) across the battery terminals followed by the voltage across the bulb's contact points.

Points	V_{PhET} , volts	V_{lab} , volts
V_{batt}		
V_{bulb}		

- iii) Connect an ammeter to measure the current that flows through the circuit. Record your reading. Note that an ammeter MUST be connected in series with the bulb (You must break the circuit connection in order for you to insert the ammeter).



- iv) Add another bulb in the circuit, observe the brightness of the bulbs and repeat steps (ii) and (iii).
 v) Add yet another bulb in the circuit, observe the brightness of the bulbs and repeat steps (ii) and (iii).



PhET Bulbs in Series	Brightness	V_{AB} V	$V_{\text{bulb-1}}$ V	$V_{\text{bulb-2}}$ V	$V_{\text{bulb-3}}$ V	I_{AB} A	Power Watts
Bulb 1				none	none		
Bulb 1 + Bulb 2					none		
Bulb 1 + Bulb 2 + Bulb 3							
LAB Bulbs in Series	Brightness	V_{AB} V	$V_{\text{bulb-1}}$ V	$V_{\text{bulb-2}}$ V	$V_{\text{bulb-3}}$ V	I_{AB} A	Power Watts
Bulb 1				none	none		
Bulb 1 + Bulb 2					none		
Bulb 1 + Bulb 2 + Bulb 3							

- v) Unscrew any bulb and observe what happens to the bulbs and to the current in the circuit. Record your observation.

Questions

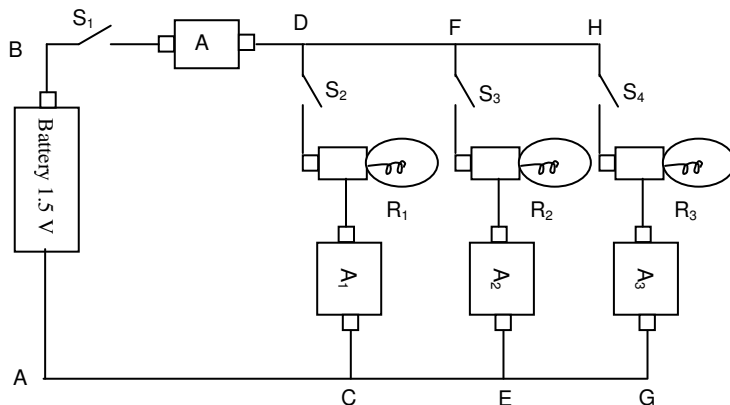
1. What causes the bulb to light up when the switch is thrown down?
2. Why did the bulb go off when it is unscrewed from the holder?
3. Did it matter if the polarity of the bulb is reversed? Why or why not?
4. Why is the voltage the same when measured across the battery or across the bulb for a single circuit?
5. What is the physical meaning of the current reading on the ammeter?
6. What happens to the brightness of the first bulb, the voltage across it and the current in the circuit when a second bulb is added in series to the circuit?

7. What happens to the brightness of the first bulb, the voltage across it and the current in the circuit when a third bulb is added in series to the circuit?
8. Can you propose a model on how the brightness of the bulbs change as the number of bulbs are increased or decreased in a series circuit?
9. Is there a relationship between the number of bulbs and the current in a circuit?
10. How can this brightness model be related to the electrical power?
11. What happens to the current in the circuit when any one of the bulbs is unscrewed? Explain.

Investigation 2 - Bulbs in Parallel

Prediction 2.1: (The battery shown in the figure below is a 1.5 V battery)

- i) Will all the bulbs in the parallel circuit have the same brightness?
- ii) What will the voltmeter reading be if the probes are connected between points A and B and between C and D respectively for the bulbs connected in parallel?
- iii) Would the voltage reading change if the probes are placed across the terminals of the second bulb (between E and F), and across the terminals of the third bulb (between G and H)?
- iv) Would you consider the contact points at point B, D, F and point H to be an equipotential point?
- v) Will the current going through the circuit the same as the current through the first bulb, the second bulb or the third bulb?
- vi) What will happen to the brightness if one bulb is unscrewed, if 2 bulbs are unscrewed? What happens to the current in the circuit?



Activity 2.1: (You MUST run the PhET (Circuit Construction Kit (DC only)) simulation first before attempting to do the following activities in the lab. Set the battery voltage to 1.5 V and the resistance for each bulb at 1.0 Ω)

- i) Connect the bulbs in parallel as shown in the figure but start with 2 bulbs followed by three bulbs. Observe the brightness of the bulbs as more bulbs are added in parallel. Then, using a multimeter with the dial set on DC mode, measure the voltage across the battery, V_{AB} , the voltage across the first bulb, V_{CD} , the voltage across the second bulb, V_{EF} , and the voltage across the third bulb, V_{GH} . Record your reading.

PhET Bulbs in parallel	V_{AB} V	V_{CD} V	V_{EF} V	V_{GH} V
Bulb 1			none	none
Bulb 1 + Bulb 2				none
Bulb 1 + Bulb 2 + bulb 3				
LAB Bulbs in parallel	V_{AB} V	V_{CD} V	V_{EF} V	V_{GH} V
Bulb 1			none	none
Bulb 1 + Bulb 2				none
Bulb 1 + Bulb 2 + bulb 3				

- ii) Now place an ammeter between points B and D. Record your reading. Then place an ammeter between points C and D and also between points E and F and between G and H. Record your reading.

PhET Bulbs in parallel	I_{BD} A	I_{CD} A	I_{EF} A	I_{GH} A	Power Watts
Bulb 1		none	none	none	
Bulb 1 + Bulb 2				none	
Bulb 1 + Bulb 2 + bulb 3					
LAB Bulbs in parallel	I_{AB} A	I_{CD} A	I_{EF} A	I_{GH} A	Power Watts
Bulb 1		none	none	none	
Bulb 1 + Bulb 2				none	
Bulb 1 + Bulb 2 + bulb 3					

- iii) Unscrew the first bulb. Observe the brightness of the remaining bulbs and write your observation. Then record all the ammeter readings.
- iv) Unscrew the second bulb leaving only the third bulb in the circuit. Observe the brightness of the remaining bulb and write your observation. Then record all the ammeter readings.

PhET Bulbs in parallel	I_{BD} A	I_{CD} A	I_{EF} A	I_{GH} A	Power Watts
Bulb 1 unscrewed					
Bulbs 1 & 2 unscrewed					
LAB	I_{AB} A	I_{CD} A	I_{EF} A	I_{GH} A	Power Watts
Bulb 1 unscrewed					
Bulbs 1 & 2 unscrewed					

Questions

1. What happens to the brightness of the first bulb and the current through it when a second bulb is added in parallel to the circuit? What about the power?
2. What happens to the brightness of the first bulb and the current through it when a third bulb is added in parallel to the circuit? What about its power?
3. Is there a relationship between the number of bulbs and the total current in a circuit?

4. Can you propose a model on how the brightness of the bulbs change as the number of bulbs are increased or decreased in a parallel circuit? What about a model for the power?
5. What happens to the current in the circuit when any one of the bulbs is unscrewed? What about its power?
6. What happens to the total voltage and the voltages across the bulbs as more bulbs are added?
7. What happens to the total current as more bulbs are added?
8. What happens to the total power as more bulbs are added?