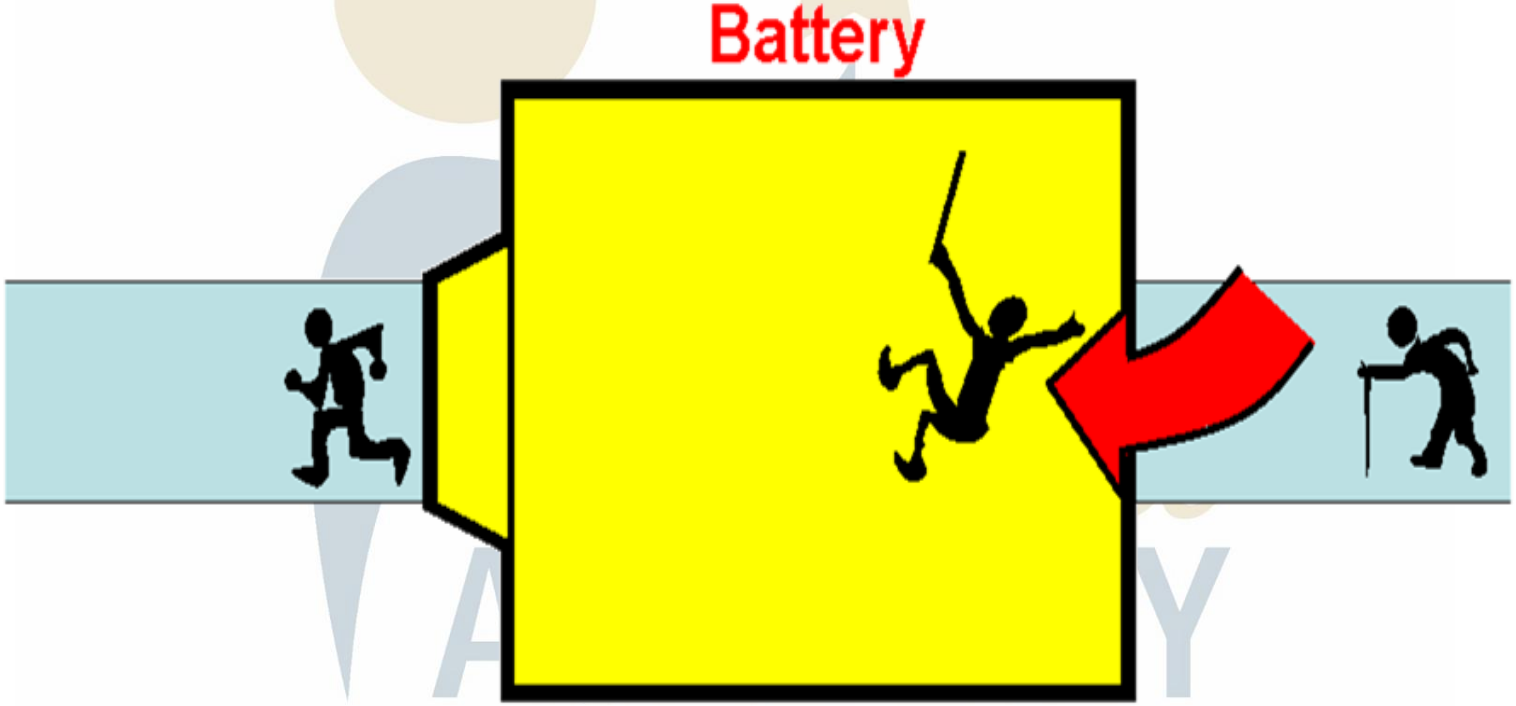
Physics – Grade 10

Unit One – Electricity

Chapter 2 – Potential Difference



Prepared & Presented by: Mr. Mohamad Seif

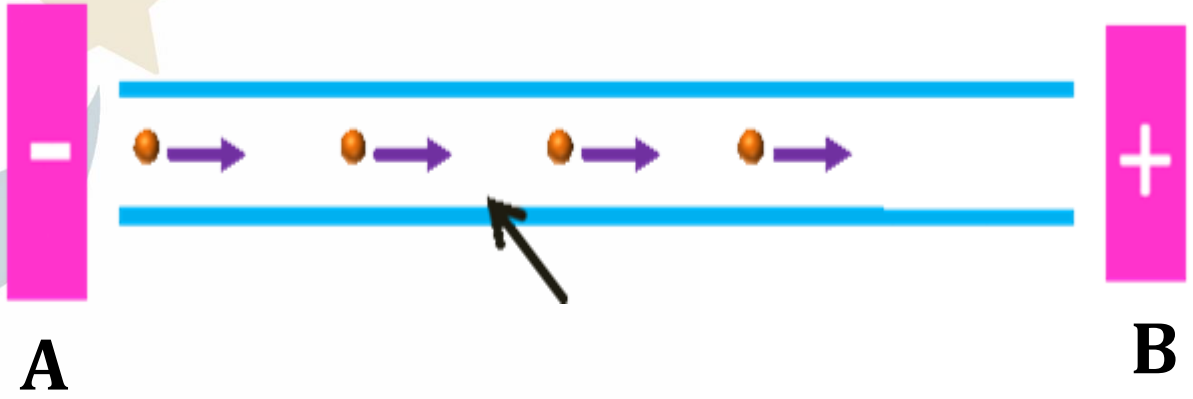
OBJECTIVES

1. Definition of electric potential & potential difference
2. Identify electric components

Electric Potential

Electric charges flow from A to B, since they are not at the same electric potential.

The flow of charges stop when A & B become at same potential $V_A = V_B$



Electric potential:

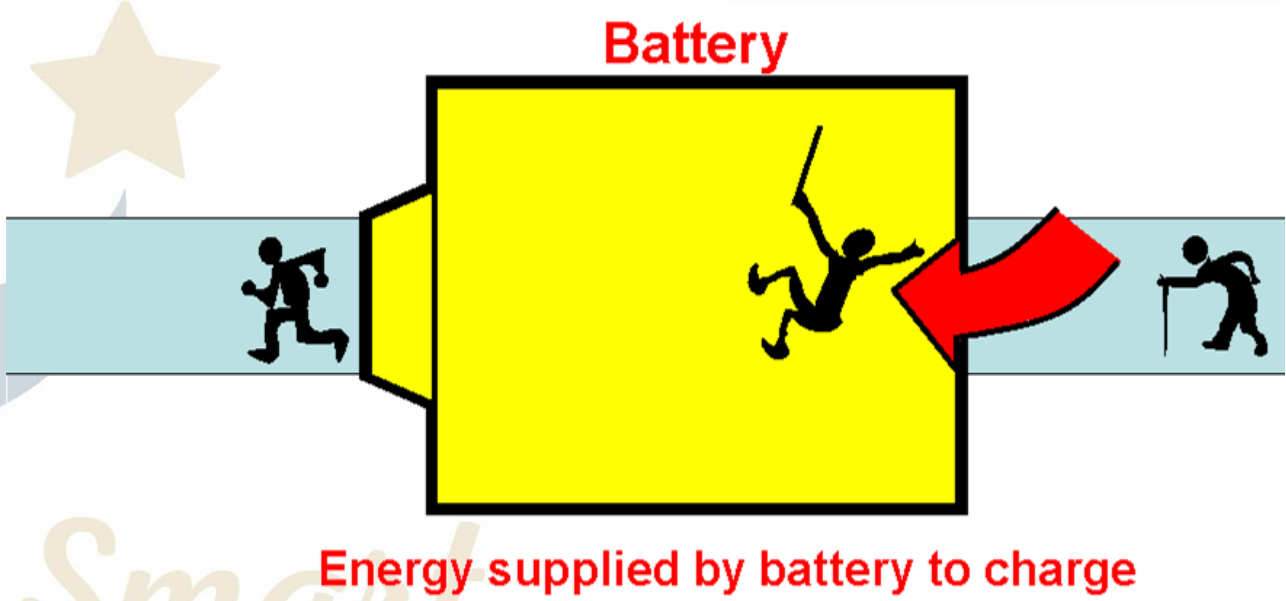
Electric potential: at a given point is a physical quantity which depends on the value, sign, and position of the charge in the region around this point.

In S.I the electric potential expressed in volts (V).

Electric Potential difference

The battery transfers energy to the electrons to move them to the negative pole.

Thus, the battery keeps the electrons circulating round the circuit by maintaining a difference in electric potential between A and B.



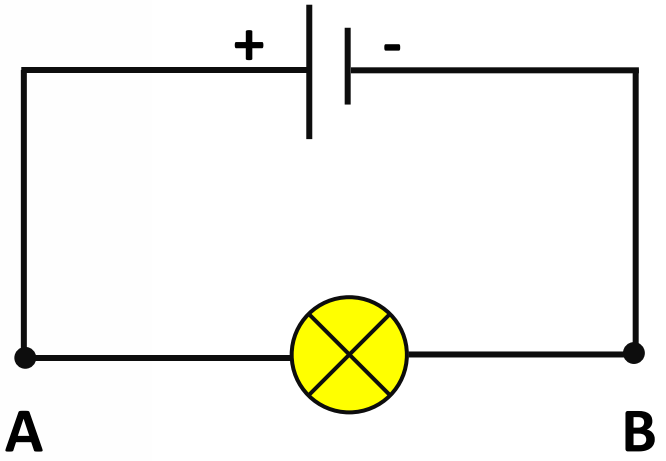
The potential difference (voltage) between A and B is:

$$V_{AB} = V_A - V_B$$

Electric Potential difference

The difference of electric level between two points A and B is called potential difference.

The potential difference between two points A and B can be positive or negative.



$$V_{AB} = V_A - V_B \quad \text{And} \quad V_{BA} = V_B - V_A$$

$$\boxed{V_{BA} = -V_{AB}}$$

Electric Potential difference

Application 1:

In an electric circuit, the following electric potentials are given: $V_P = 3.7V$; $V_N = 0V$ and $V_B = 1.3V$.

1) Calculate the potential difference V_{PB} and V_{NB}.

$$V_{PB} = V_P - V_B \Rightarrow V_{PB} = 3.7 - 1.3 \Rightarrow V_{PB} = 2.4V$$

$$V_{NB} = V_N - V_B \Rightarrow V_{NB} = 0 - 1.3 \Rightarrow V_{PB} = -1.3V$$

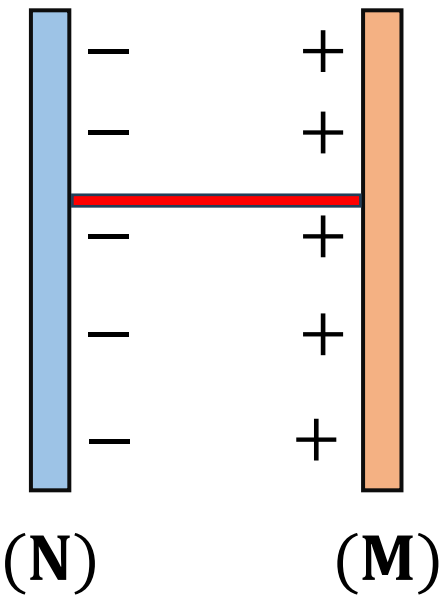
2) B and P are the terminals of a lamp. Specify the direction of electrons in this lamp.

Since $V_B < V_P$ then electrons flow from B to P

Electric Potential difference

Application 2:

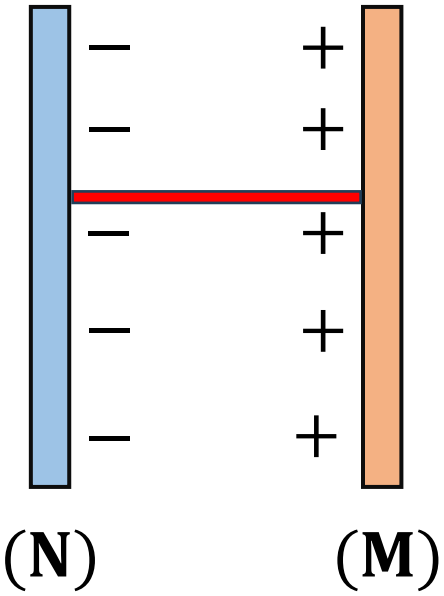
Consider two charged metallic plates M and N as shown in the figure. When a connecting wire joins M and N, the electric charge flow between them.



1) **Determine the direction of flow of electrons.**
2) **Deduce whether the electric potential V_M is higher or lower than the electric potential V_N**
3) **Give the relation between V_M and V_N, when electric equilibrium attained.**

Electric Potential difference

1) Determine the direction of flow of electrons.



The electrons flow from (N) to (M)

2) Deduce whether the electric potential V_M is higher or lower than the electric potential V_N

Electrons flow from low potential to high potential and therefore $V_N < V_M$.

3) Give the relation between V_M and V_N, when electric equilibrium attained.

The transfer of electrons stops when electric equilibrium is attained. Then $V_M = V_N$

Electric components

A battery (dry cell) is a source of voltage

A battery has two different poles positive (+) and negative (-)

Dry Cell
9 V

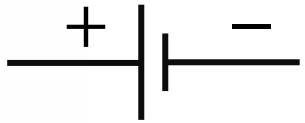
Dry Cell
12 V

Electric components

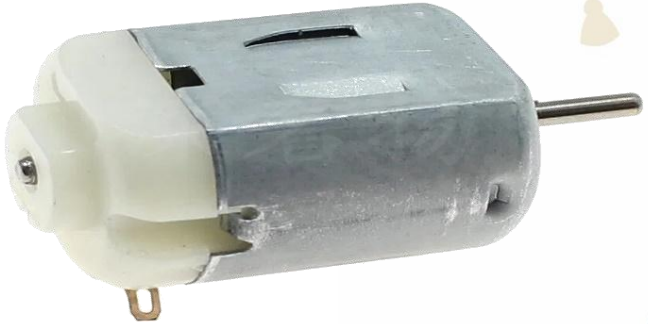
Connecting wires

Lamp

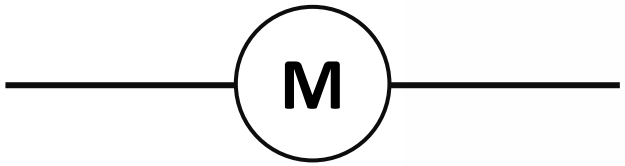
Battery



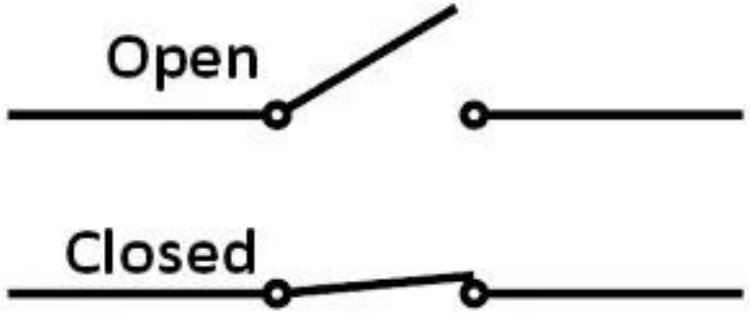
Electric components



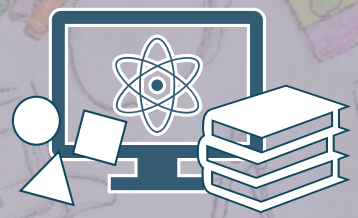
Motor



Switch



The End



OBJECTIVES

3 Use voltmeter to measure potential difference

4 Use oscilloscope to measure potential difference

Measurement of Potential Difference

The Potential difference (P.D) can be measured by using:

- Multi-meter
- Analog voltmeter
- Oscilloscope

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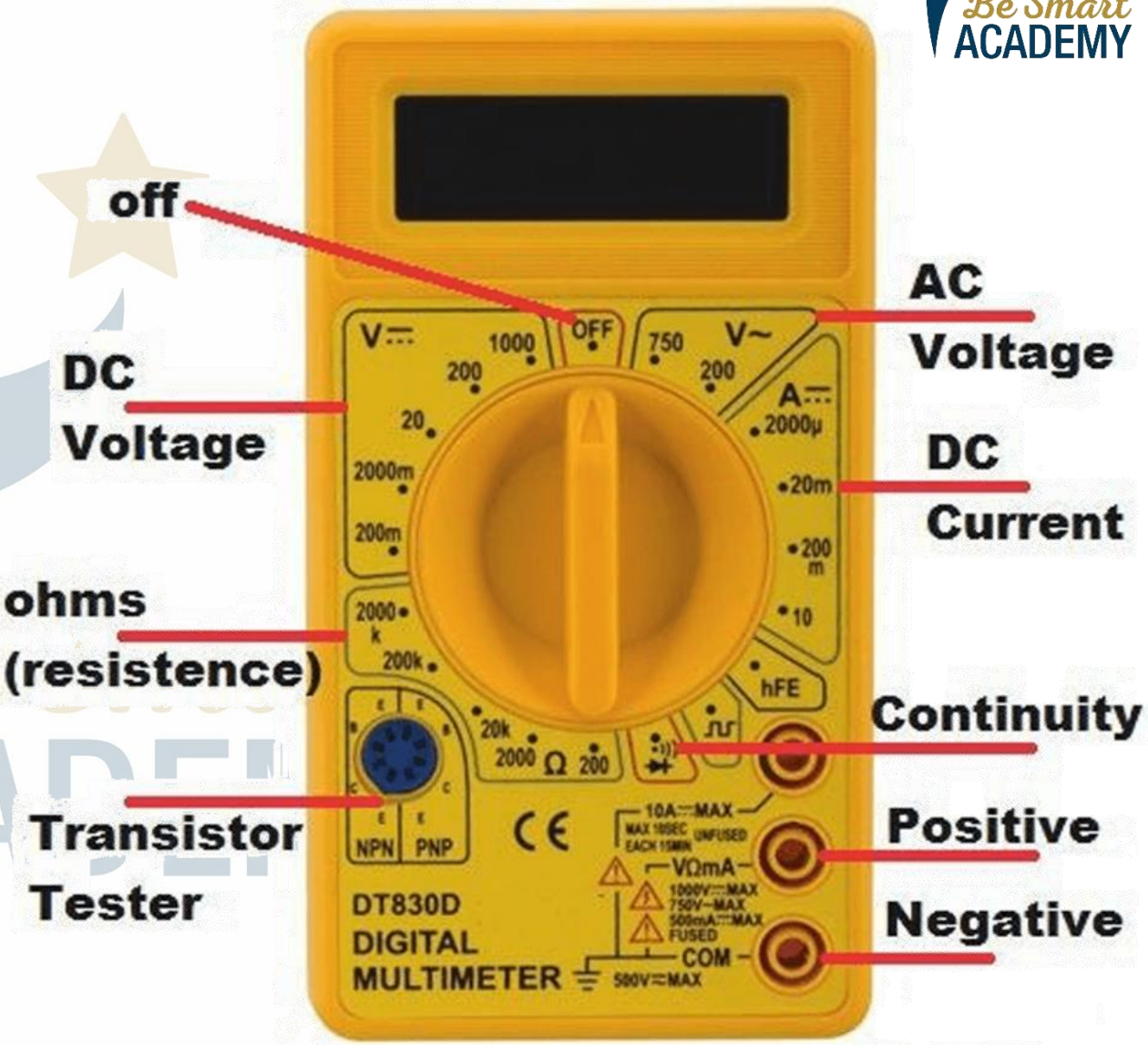
Measurement of Potential Difference/ Voltmeter

Multi-meter:

Multi-meter is a measuring instrument that can measure multiple electrical properties.

A multimeter can measure voltage, resistance, and current, in which case can be used as a voltmeter, ohmmeter, and ammeter.



Measurement of Potential Difference/ Voltmeter

In this lesson we use the Multi-meter as voltmeter to measure the potential difference (voltage).

The Voltmeter is connected in parallel with the needed load to measure its voltage.

The symbol of voltmeter is:

Measurement of Potential Difference/ Voltmeter

This voltmeter has scales (ranges) of measurement: $1000V$; $200V$; $20V$; $2000mV$ and $200mV$

The scale is the largest value of the voltage that could be measured.

If the chosen scale is 20V, then the maximum voltage that could be measured by this voltmeter is 20V.

Measurement of Potential Difference/ Voltmeter

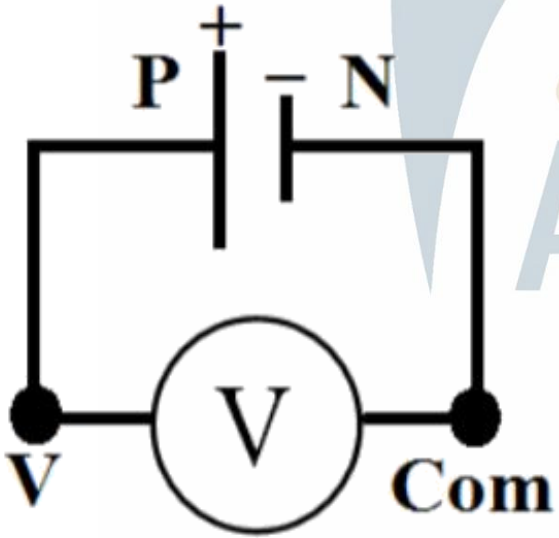
The most convenient scale should be slightly greater than the measured voltage.

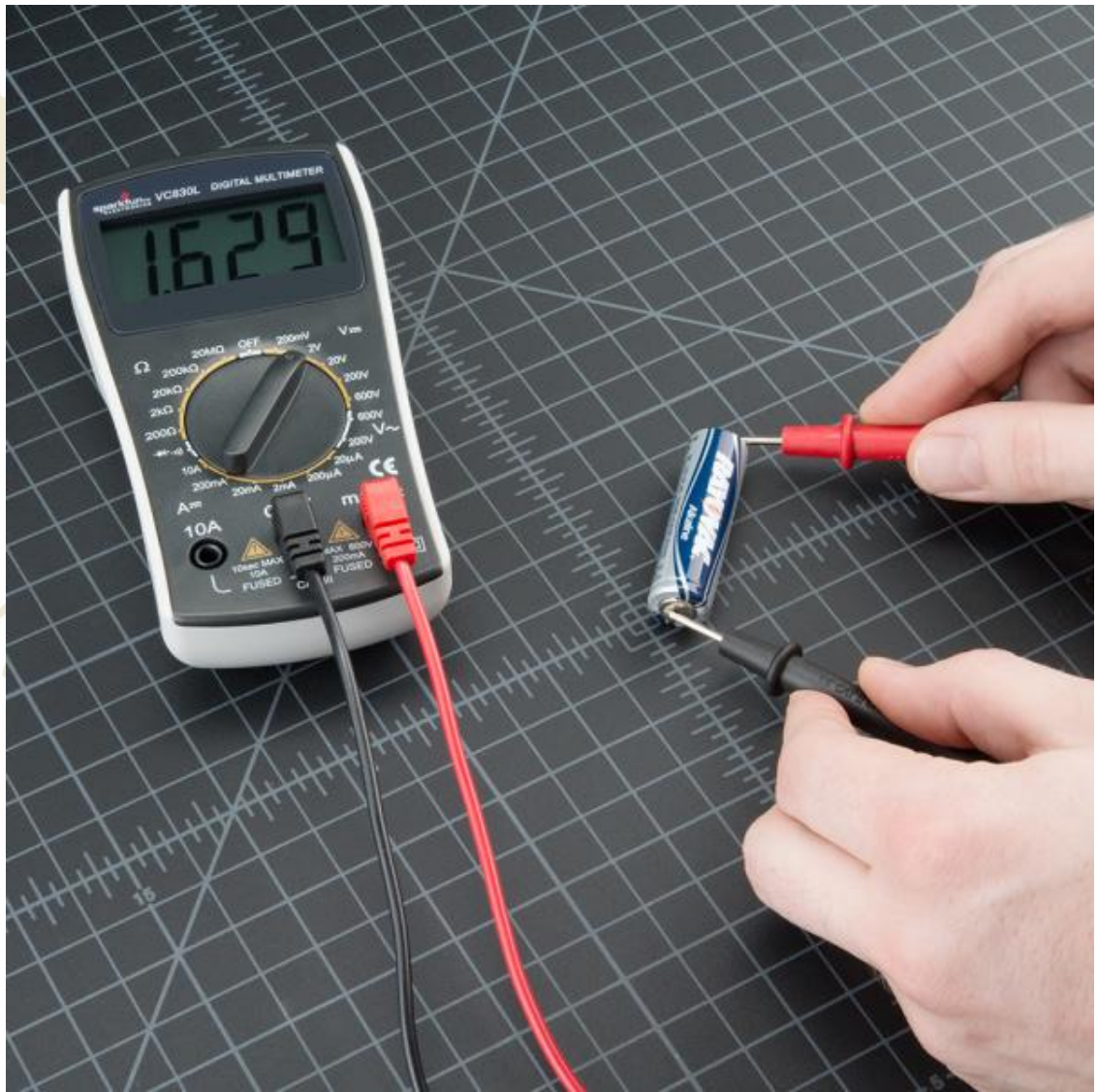
It gives the most accurate value of the measured potential difference.

Measurement of Potential Difference/ Voltmeter

Connect the (V) terminal of voltmeter to the positive pole of dry cell and the (com) of voltmeter to the negative pole of dry cell:

The reading on the voltmeter is positive

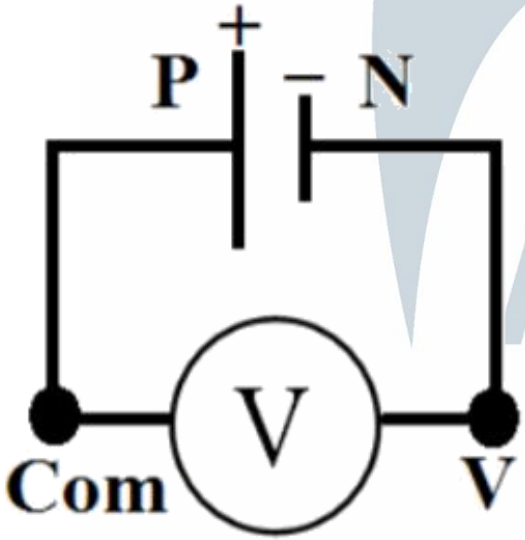




Measurement of Potential Difference/ Voltmeter

Connect the (V) terminal of voltmeter to the negative pole of dry cell and the (COM) terminal to the positive pole of dry cell:

The reading on the voltmeter is negative

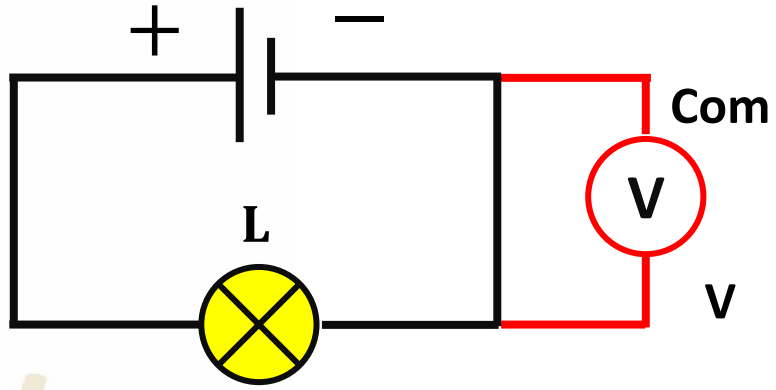


Measurement of Potential Difference/ Voltmeter

Notes:

1)The voltage of the connecting wire

We connect a voltmeter across the terminals of a connecting wire:
The voltmeter indicates zero volt (0V).



$$V_{\text{cont wire}} = 0V$$

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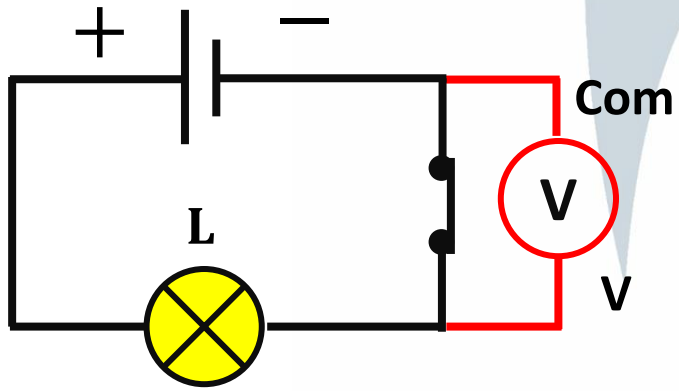
Measurement of Potential Difference/ Voltmeter

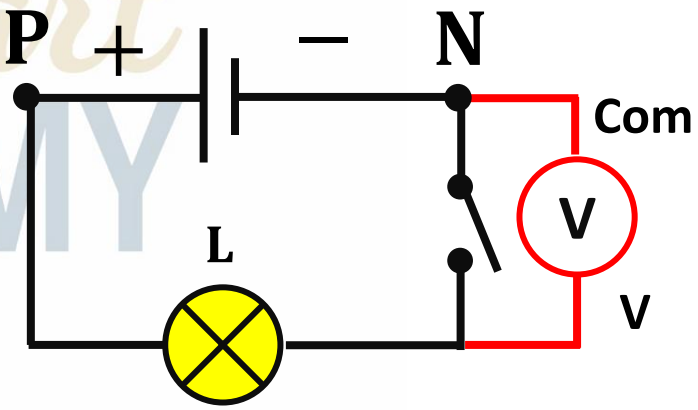
2)The voltage across opened and closed switch.

The voltmeter indicates zero volt ($0V$), since the closed switch acts as a connecting wire.



The voltmeter indicates a value equal to that of the battery

$$U_{\text{open switch}} = U_{PN}$$



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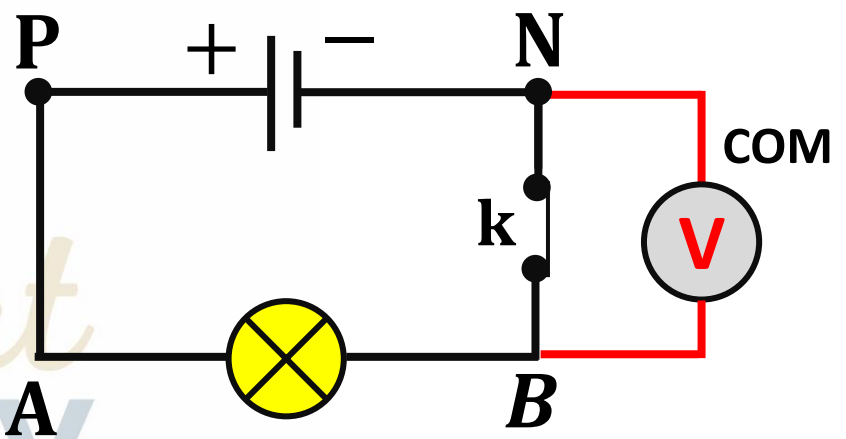
Measurement of Potential Difference/ Voltmeter

Application 3:

Consider the circuit that consists of a battery delivering a constant voltage $V_{PN} = 6V$ and a lamp as shown in the figure.

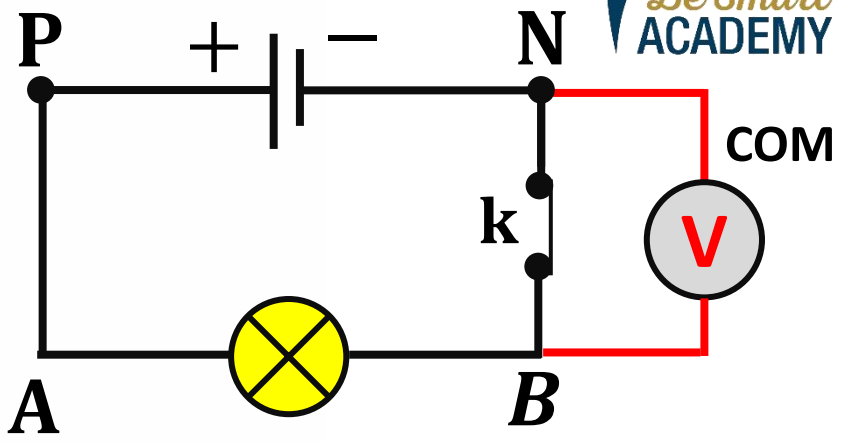
1. **Determine the voltage V_{PA}.**
2. **A voltmeter is connected between the terminals N and B. Specify the reading of the voltmeter.**
3. **If the switch is opened, determine the new reading of the voltmeter.**



Measurement of Potential Difference/ Voltmeter

1. Determine the voltage V_{PA}.

$V_{PA} = 0V$, because it is a connecting wire.



2. A voltmeter is connected between the terminals N and B. Specify the reading of the voltmeter.

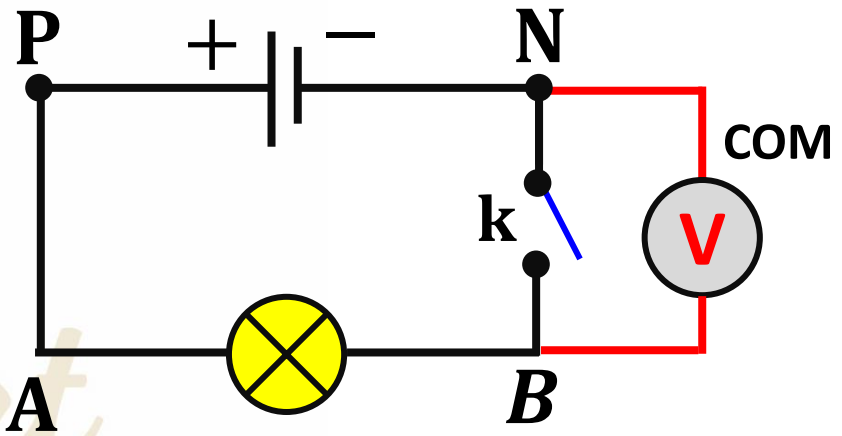
$V_{BN} = 0V$, since it is a closed switch which acts as a connecting wire.

Measurement of Potential Difference/ Voltmeter

3. If the switch is opened, determine the new reading of the voltmeter.

The voltmeter is connected to the opened switch, so its voltage is equal to that of battery.

$$V_{\text{open switch}} = V_{BN} = V_{PN} = 6V$$



Measurement of Potential Difference/ Oscilloscope

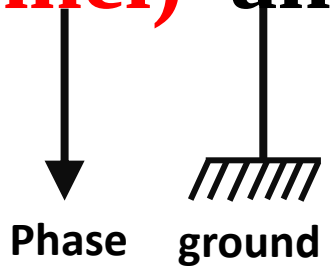
Oscilloscope is used to visualize and measure the voltage.

The displayed graph on the screen of the oscilloscope is called **oscillogram**.

Measurement of Potential Difference/ Oscilloscope

- The horizontal axis represents the time.
- The vertical axis (y) represents the voltage in volts.

- The oscilloscope has two terminals: phase (channel) and ground (mass).
- The oscilloscope reads from phase to ground.



Measurement of Potential Difference/ Oscilloscope

The functioning of an oscilloscope bases on two factors:

Vertical sensitivity (S_v): expressed in volt/division (V/div). it gives the number of volts represented by one division.

Horizontal sensitivity (S_h): expressed in millisecond/ division (ms/div). it gives the number of milliseconds represented by one division.

$$V = S_v \times y$$

- V: Voltage, expressed in volt(V).
- S_V:Vertical sensitivity, expressed in (V/div).
- y: Vertical displacement of luminous line in (div).

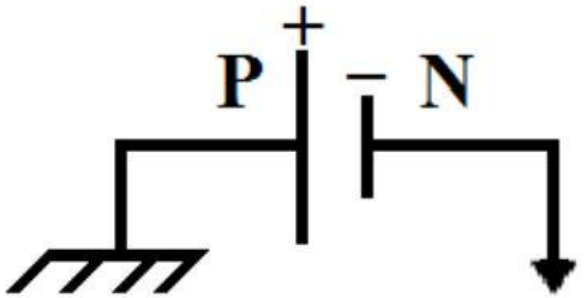
Measurement of Potential Difference/ Oscilloscope

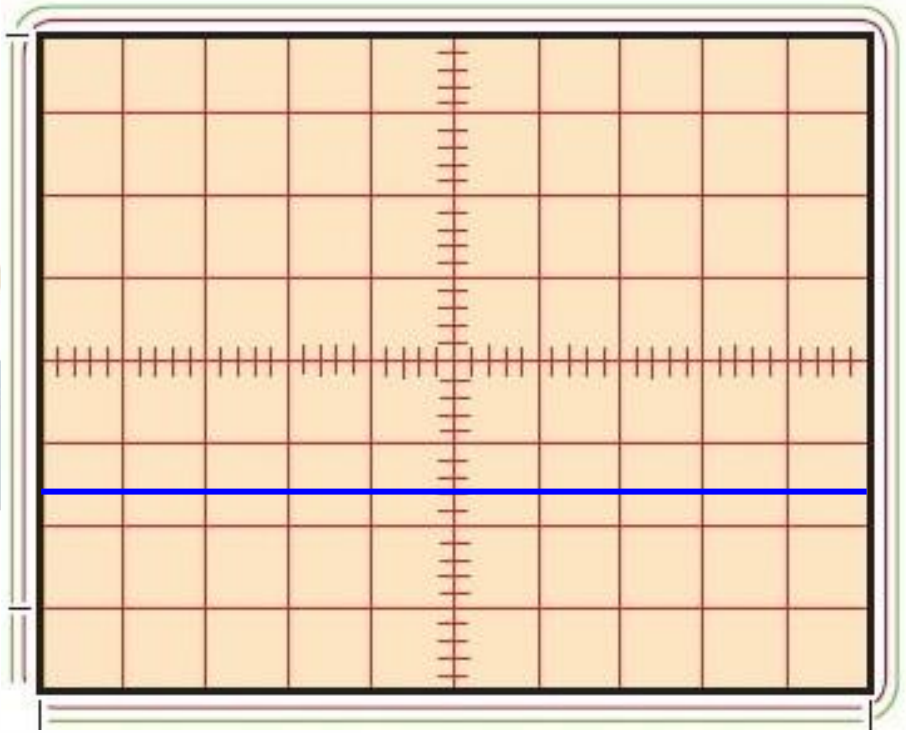
Application 5:

An oscilloscope is connected across a battery.

The oscillogram is shown. Given: $S_v = 2v/div.$

Calculate the voltage delivered by the battery.

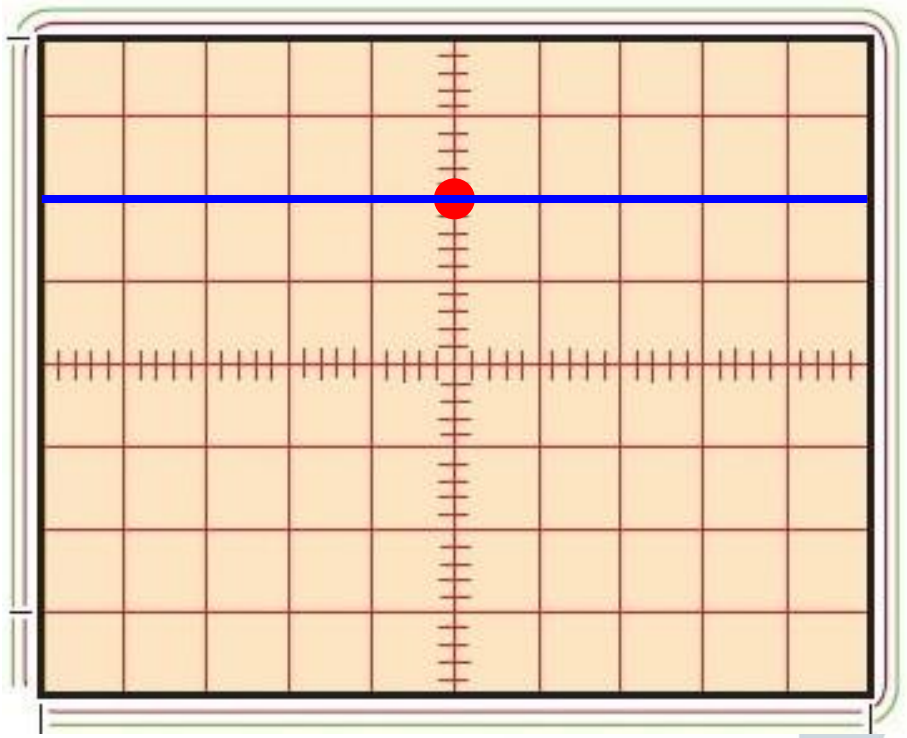




$$V_{NP} = S_v \times y$$

$$V_{NP} = 2 \times (-1.6) = -3.2V$$

Measurement of Potential Difference/ Oscilloscope



Note:

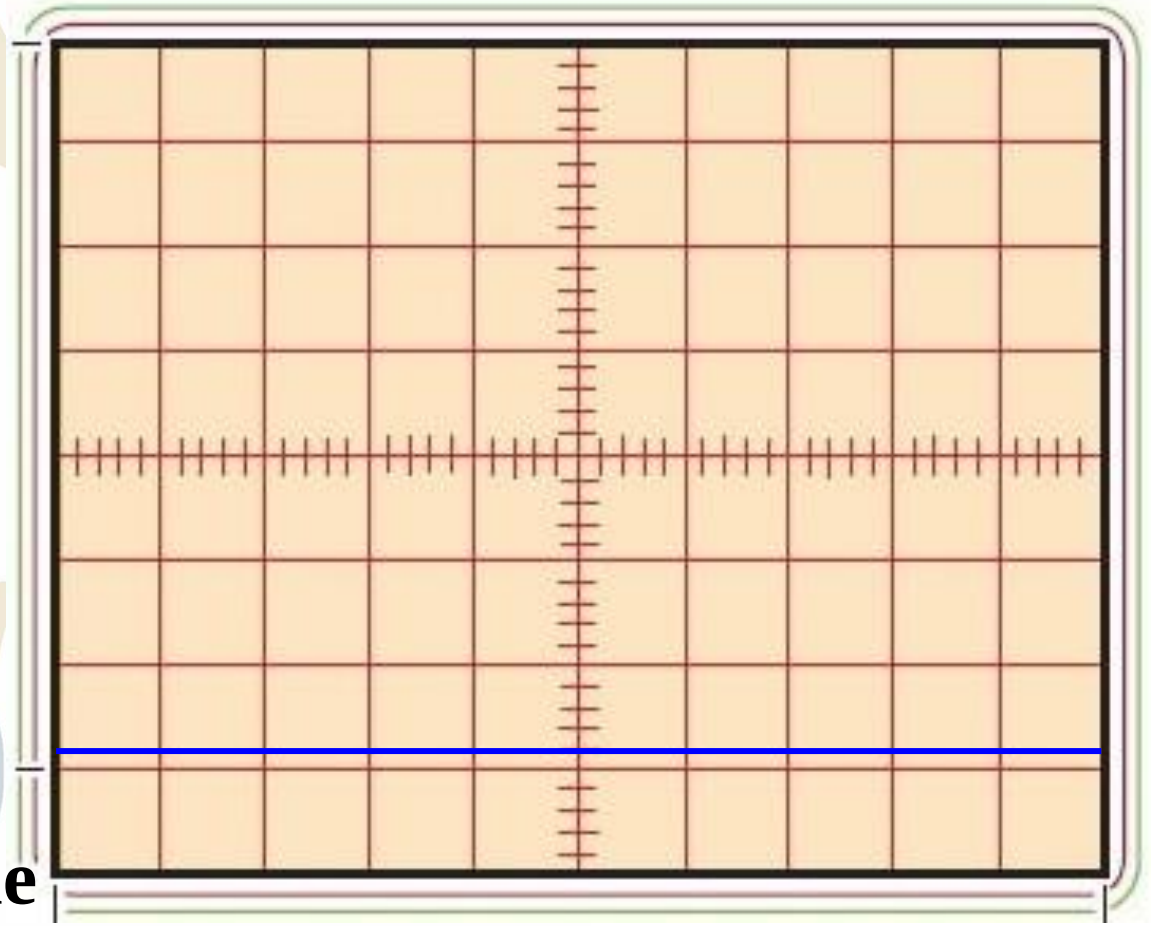
If the sweeping is turned off, then the luminous line is replaced by luminous spot in the same place.

Measurement of Potential Difference/ Oscilloscope

Application 6:

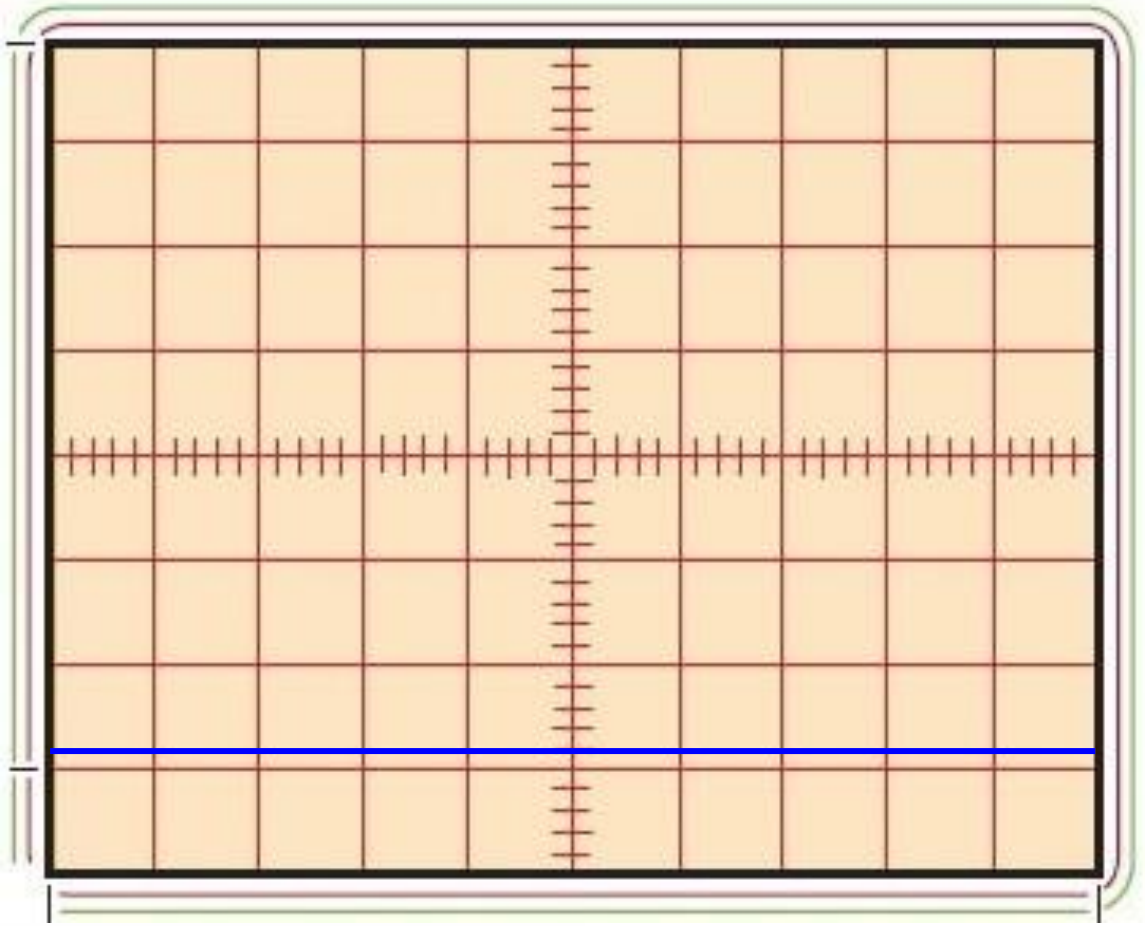
An oscilloscope is connected across the terminals of a battery delivering a constant voltage. The oscilloscope displays the oscillogram as shown.

1. **Does the oscilloscope display V_{PN} or V_{NP}? Justify.**
2. **Draw a figure representing the connection of the oscilloscope to the battery**



Measurement of Potential Difference/ Oscilloscope

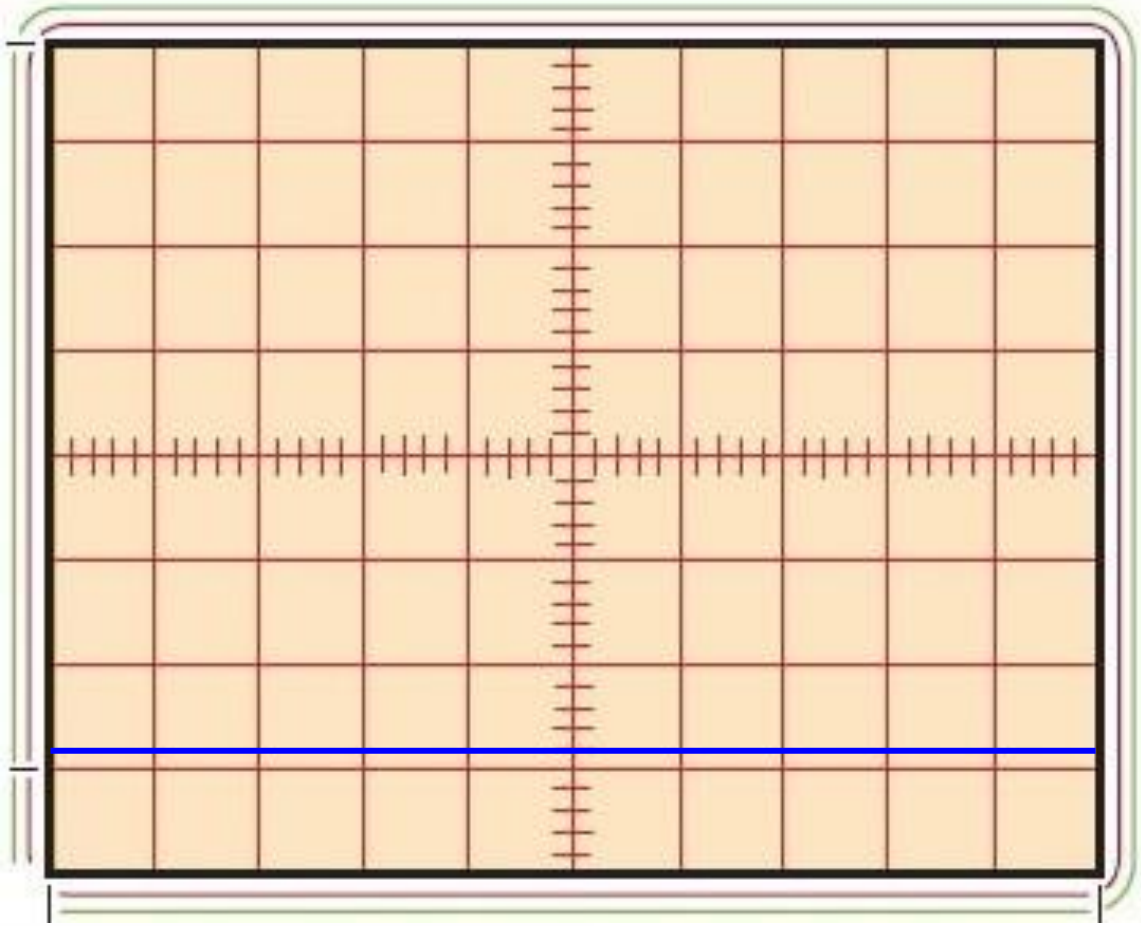
3. Knowing that the vertical sensitivity is $S_V = 2V/div$. Calculate the measured voltage.
4. What happens to the oscillogram when the terminals of the oscilloscope across the battery are reversed.
5. What happens if the sweeping is turned off.



Measurement of Potential Difference/ Oscilloscope

1. Does the oscilloscope display V_{PN} or V_{NP}? Justify.

The oscilloscope reads V_{NP} , because the luminous line moves downward from the central axis.



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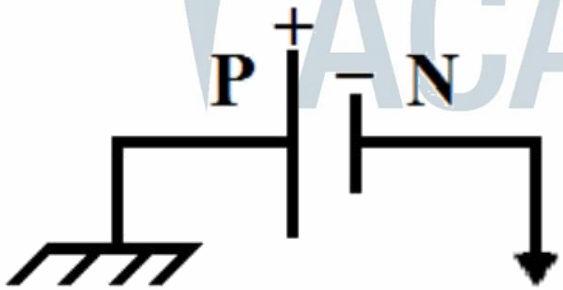
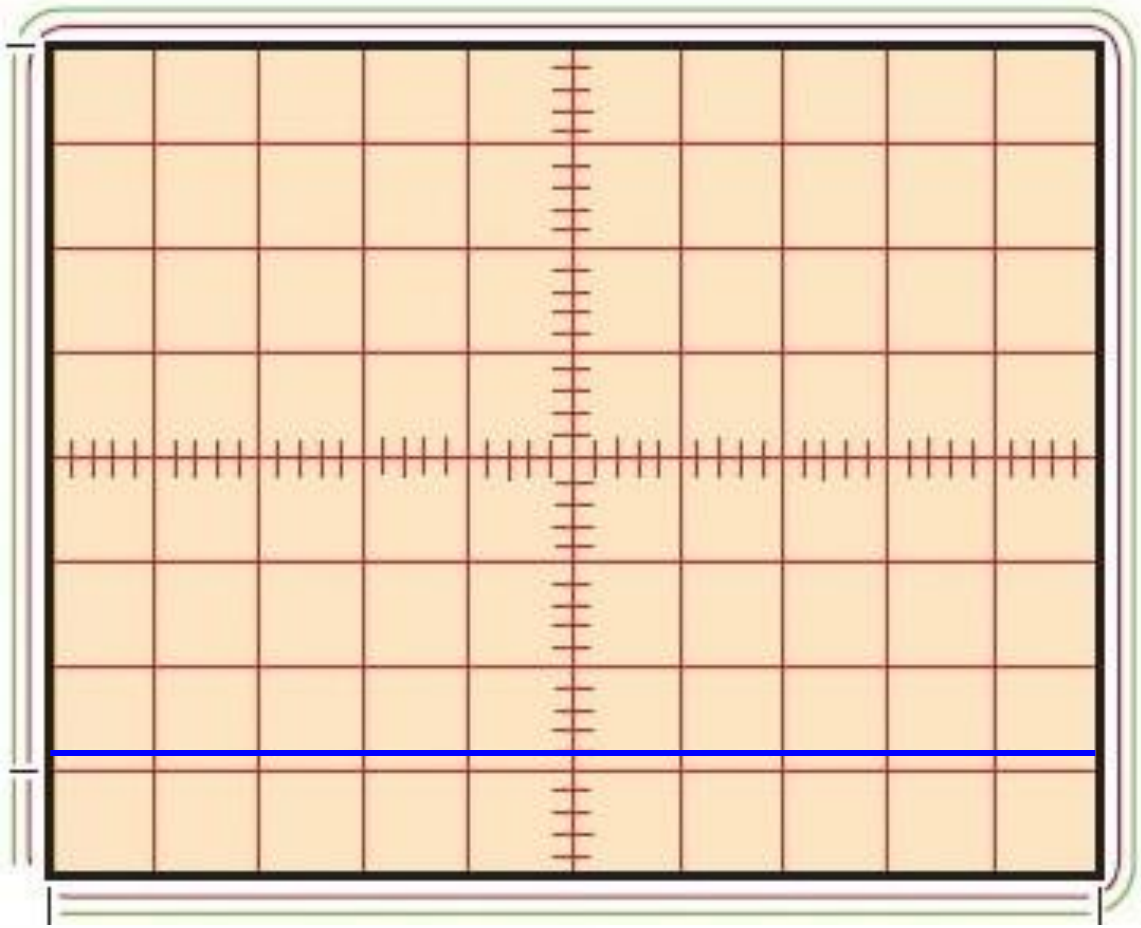


Measurement of Potential Difference/ Oscilloscope

3. Knowing that the vertical sensitivity is $S_V = 2V/div$. Calculate the measured voltage.



$$V_{NP} = S_V \times y$$

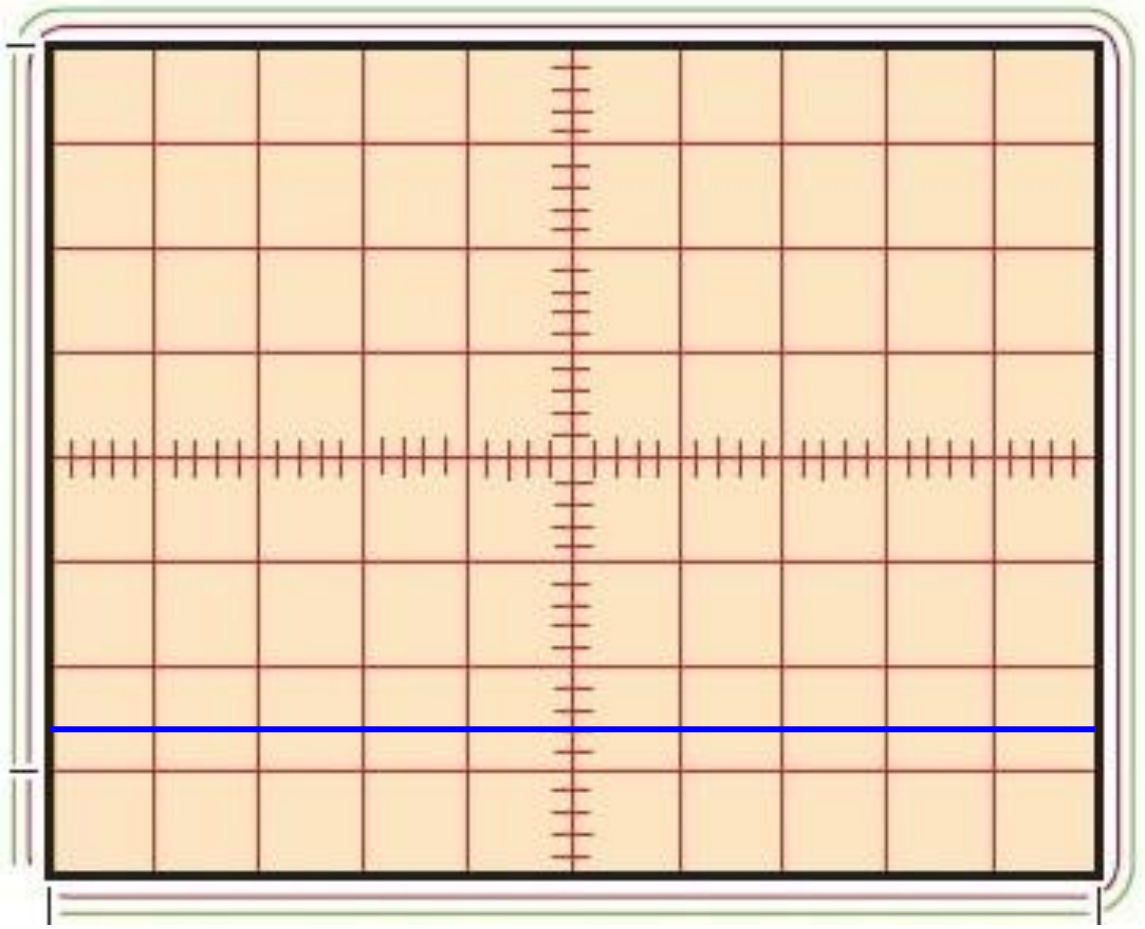
$$V_{NP} = 2 \times (-2.8)$$

$$V_{NP} = -5.6V$$

Measurement of Potential Difference/ Oscilloscope

4. What happens to the oscillogram when the terminals of the oscilloscope across the battery are reversed.

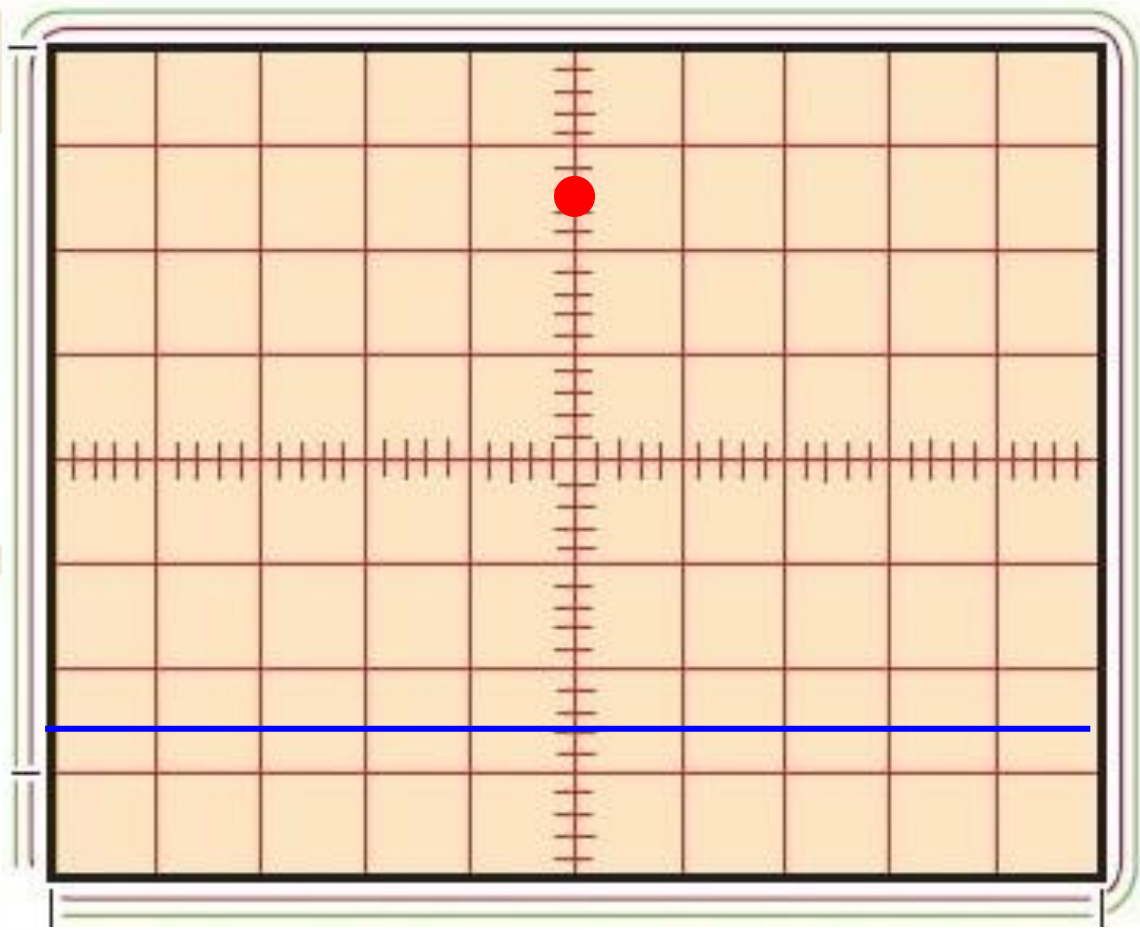
If we reverse the connection the luminous line moves up ward and the value of the voltage become positive ($V_{PN} = 5.6V$).



Measurement of Potential Difference/ Oscilloscope

5. What happens if the sweeping is turned off.

If the sweeping is turned off, then the luminous line is replaced by luminous spot in the same place



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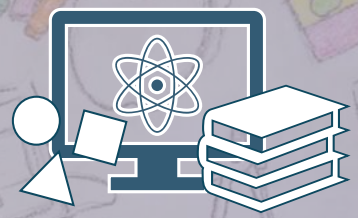


OBJECTIVES

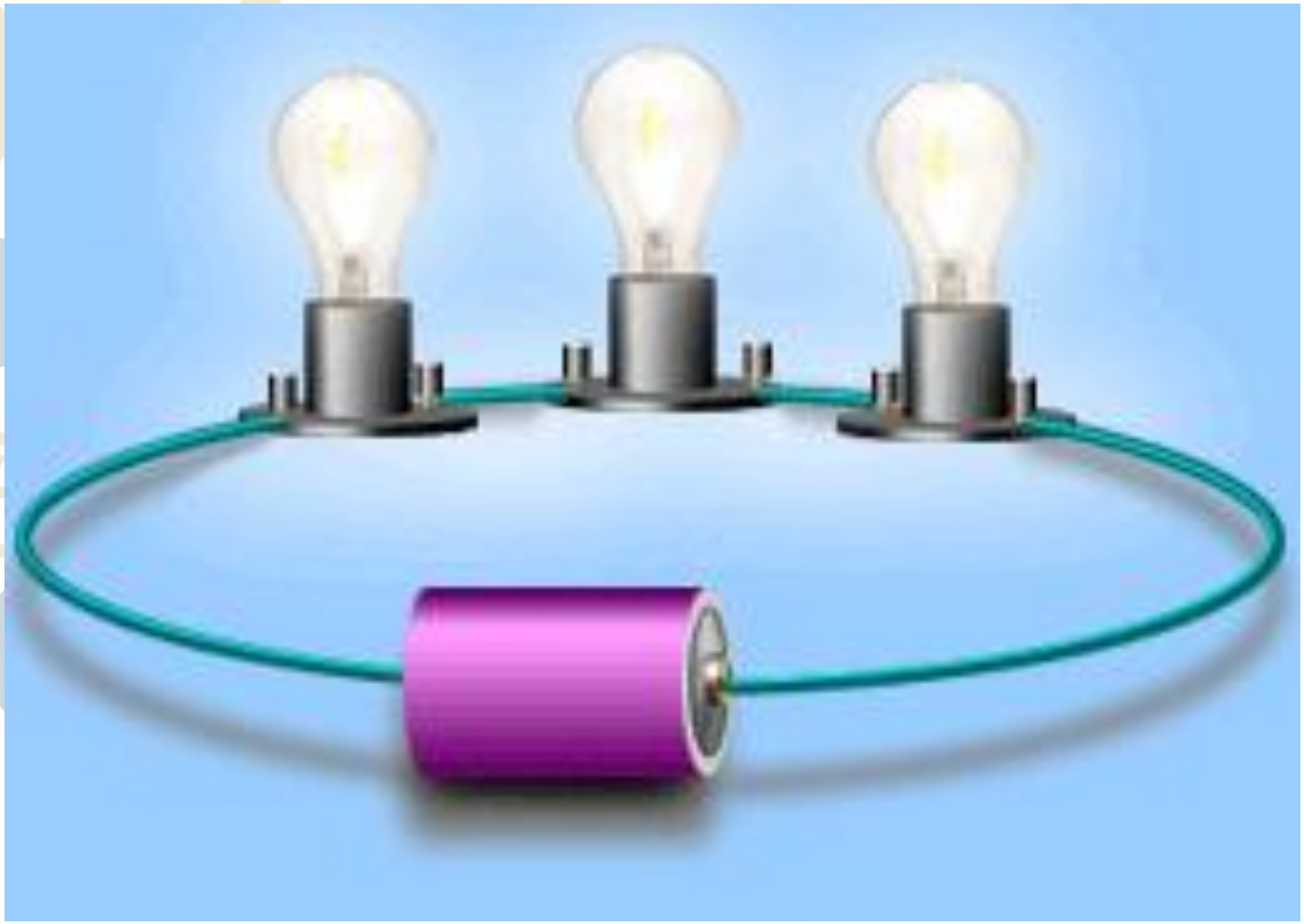
5 To apply law of potential difference in series

4 To apply law of potential difference in parallel

Grouping of Loads/ Series

The three lamps are connected in series with the battery.

In series, if one lamp burns out or removed, the other lamps turn off



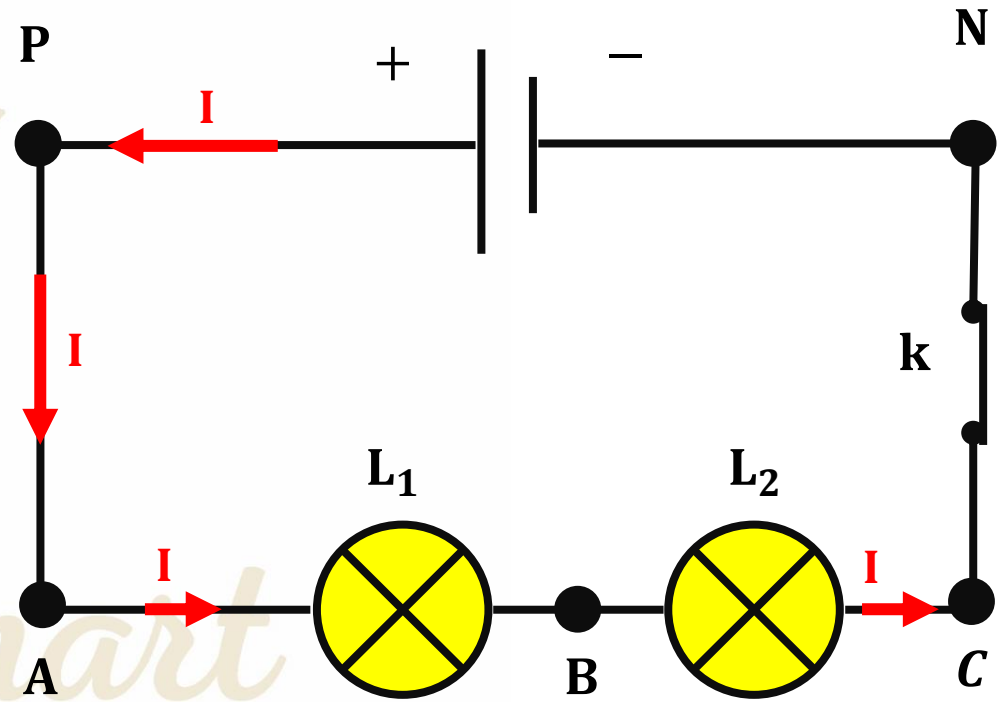
Grouping of Loads/ Series

Law of addition of voltage:

$$V_{PN} = V_{PA} + V_{AB} + V_{BC} + V_{CN}$$

$$V_{PN} = 0 + V_{AB} + V_{BC} + 0$$

$$\boxed{V_{PN} = V_{AB} + V_{BC}}$$



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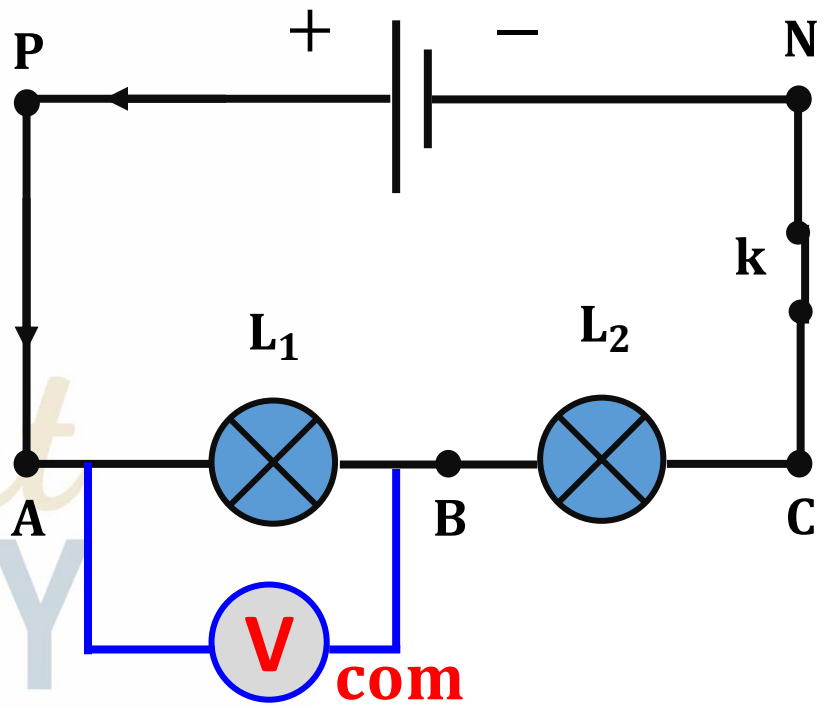
Grouping of Loads/ Series

Application 7:

Consider a battery delivers a constant voltage U_{PN}, connected across three lamps.

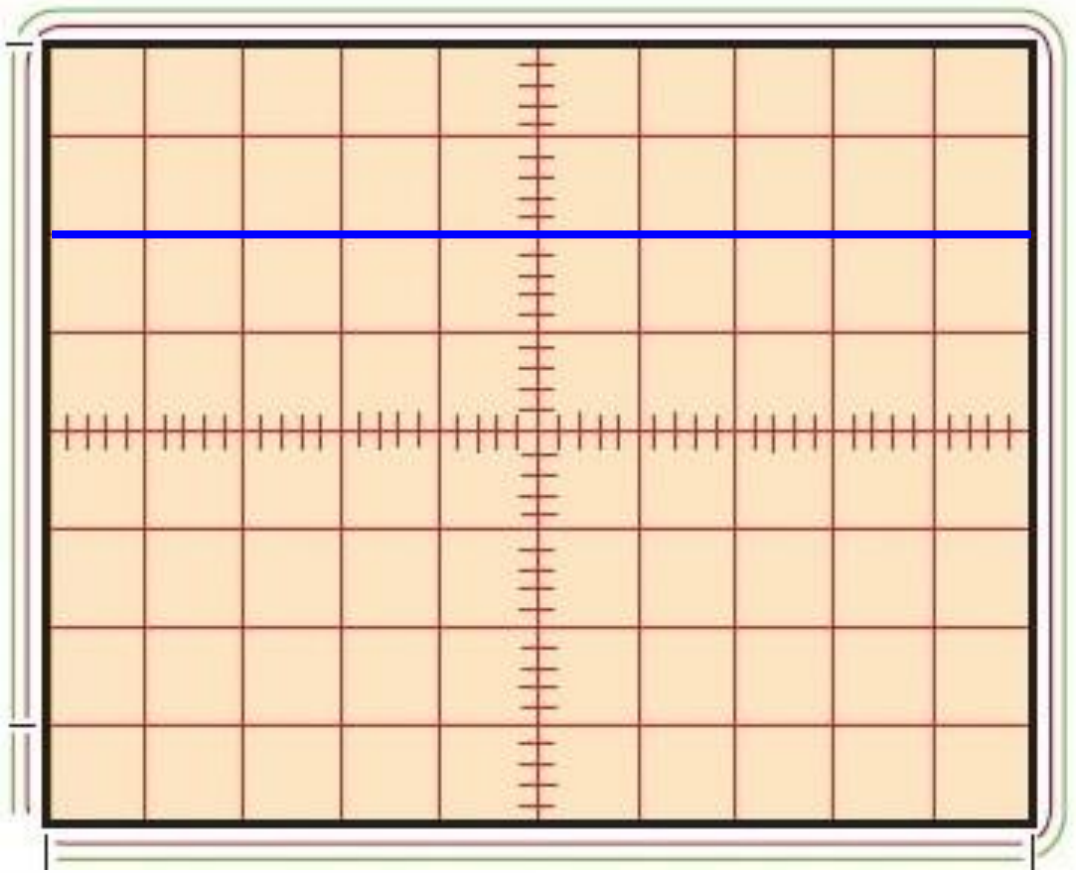
1) **A voltmeter connected across the terminals of L_1, it reads $1.5V$. Show the connections of the voltmeter across L_1.**



The Com terminal is connected to B to measure the positive value $+1.5V$

Grouping of Loads/ Series

2) An oscilloscope connected across the terminals L_2 , the oscillogram is shown. Calculate the voltage across the lamp L_2. Given $S_V = 2V/div$



$$V_{BC} = S_V \times y$$

$$V_{BC} = 2 \times 2$$

$$V_{BC} = 4V$$

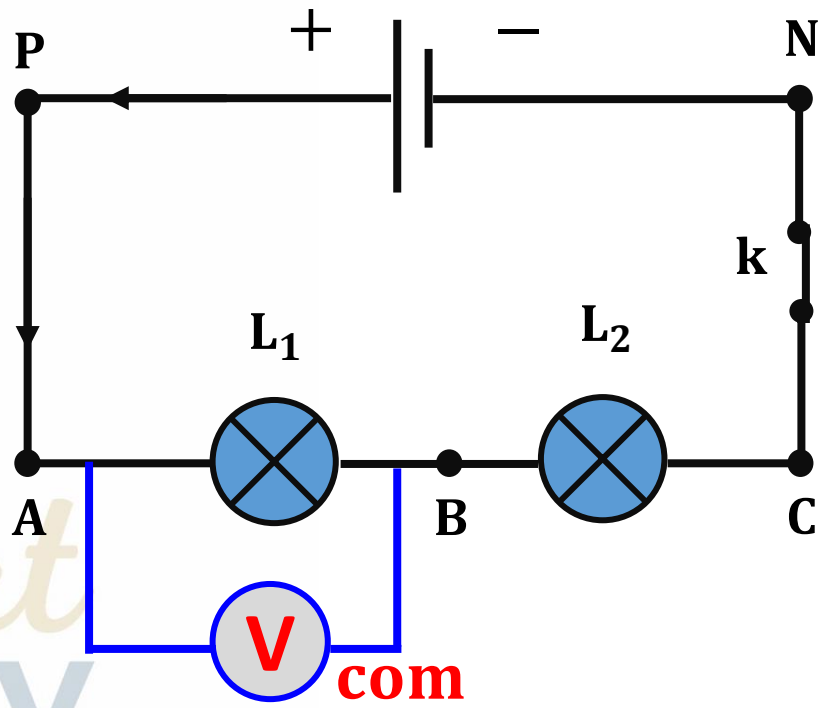
Grouping of Loads/ Series

3)Deduce the voltage U_{PN} delivered by the battery

$$V_{PN} = V_{PA} + V_{AB} + V_{BC} + V_{CN}$$

$$V_{PN} = 0 + 1.5 + 4 + 0$$

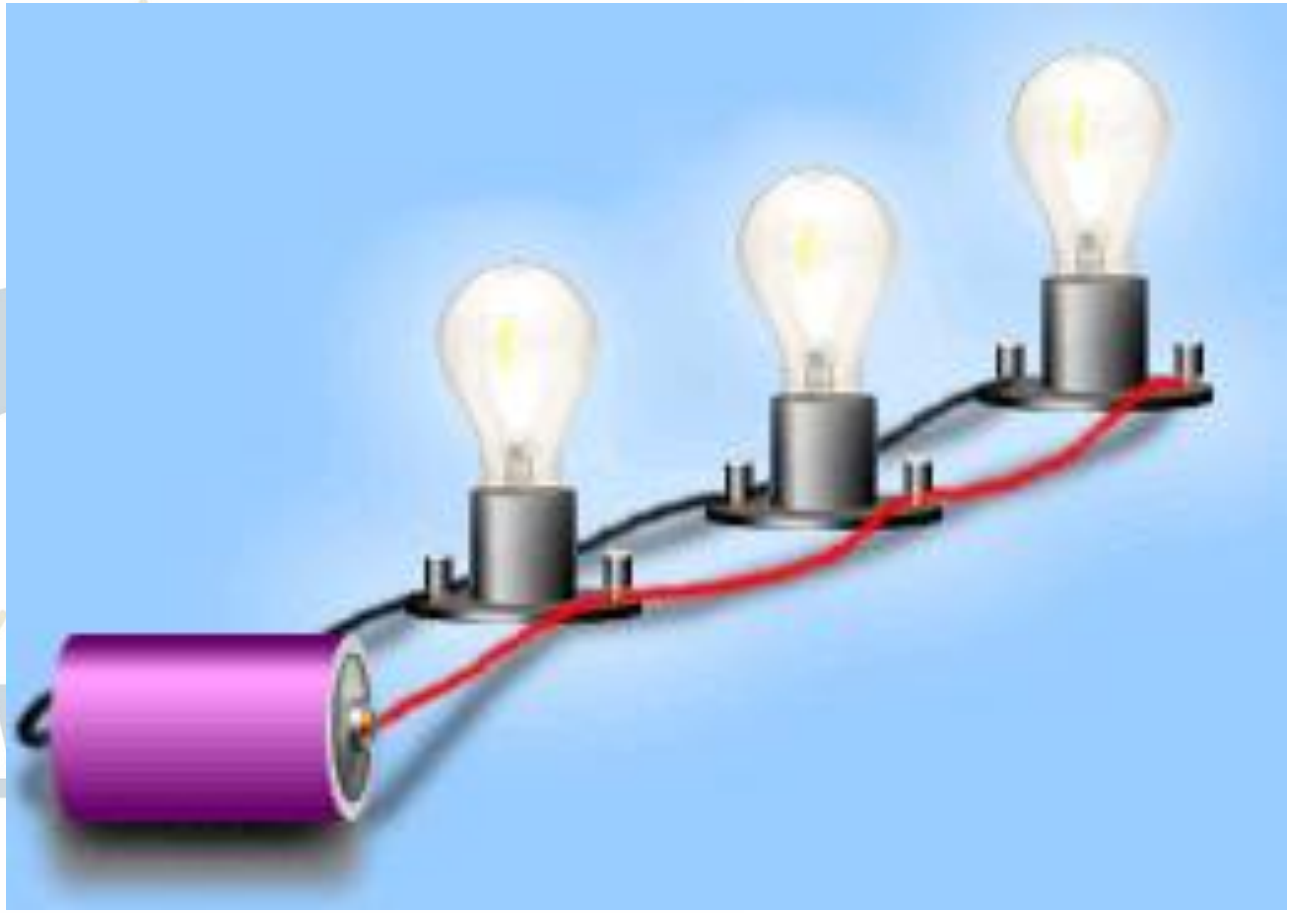
$$\boxed{V_{PN} = 5.5V}$$



Grouping of Loads/ Parallel

The three lamps are connected in Parallel with the battery.

If one lamp burns out or removed the other lamps still functions.

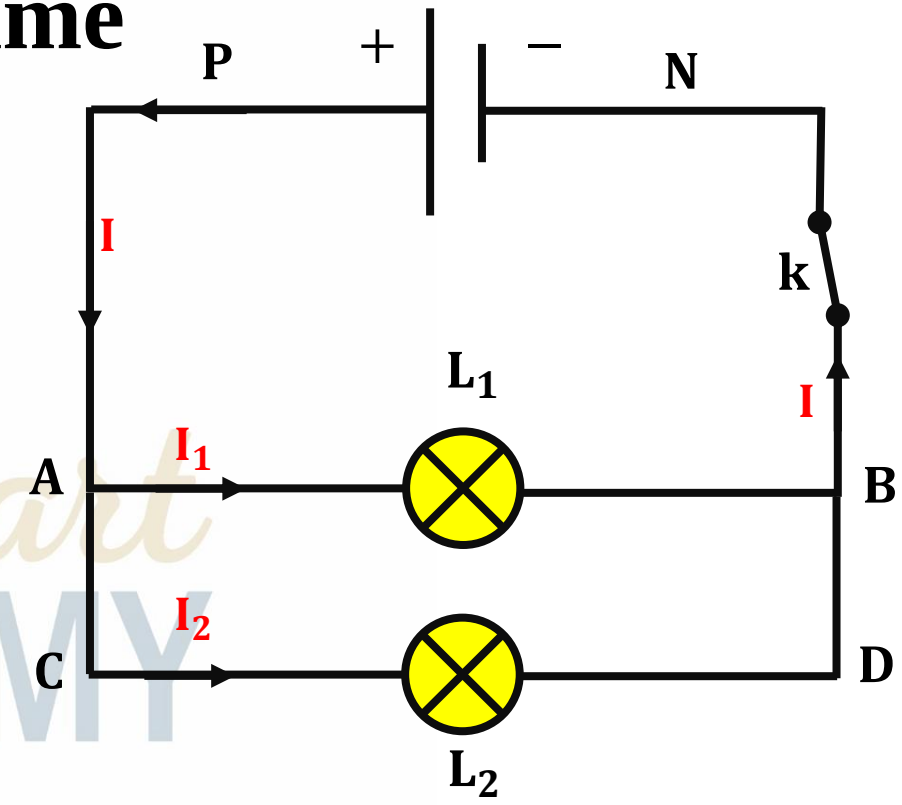


Grouping of Loads/ Parallel

Law of uniqueness of voltage in parallel:

The voltage of the battery is the same for all loads in parallel.

$$V_{PN} = V_{AB} = V_{CD}$$



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The End