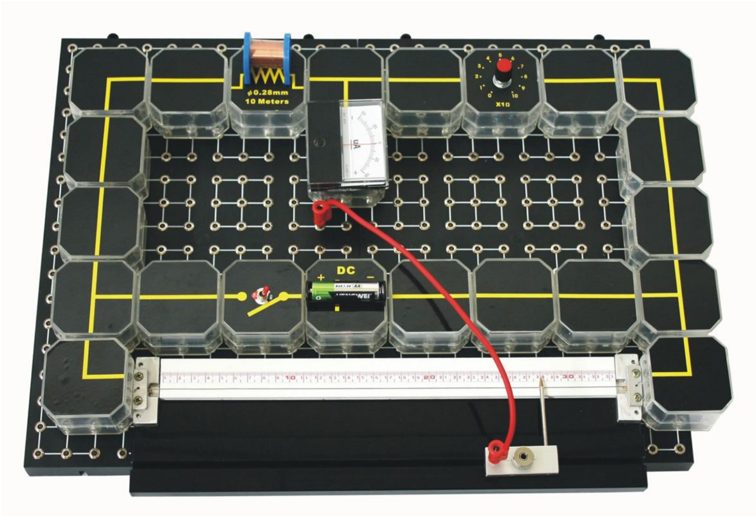
A03-200S-Y21

Electricity Demonstration Kit B



Purpose

1. Ohm's law experiment

2. Kirchhoff's law experiment

3. Wheatstone bridge experiment

A. To learn how to use a breadboard

B. To learn how to connect the circuit and use the voltage meter (voltmeter), , galvanometer (ammeter), and variable resistors.

C. To understand the relationship among voltage, current and resistance, and verify Ohm's law.

D. To learn how to calculate the voltages of each circuit using Kirchhoff's law

E. To learn how to measure the resistances using the Wheatstone bridge method.

Theory

- **Ohm's law**

the current through a conductor between two points is directly proportional to the potential difference across the two points, as shown in Fig. 3-1

V = RI
V: potential difference (V)
I: current (A)
R: resistance (Ohms)

When a conductor obeys Ohm's law, and the resistance values remain constant, the conductor potential and is related to the current regardless of how the potential difference changes.

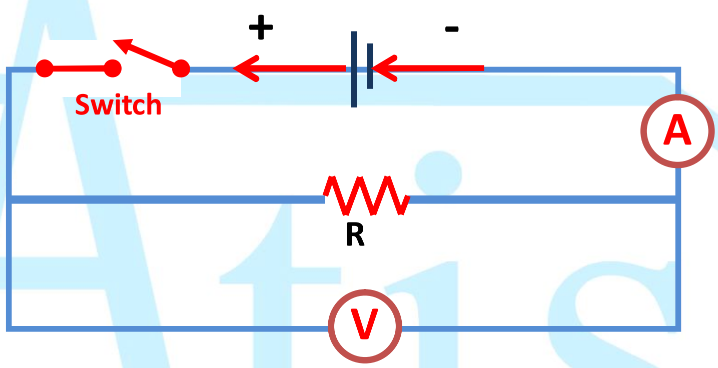


Fig. 3-1 Ohm's law

- **Kirchhoff's law**

Kirchhoff's current law(KCL): at any node in an electrical circuit, the sum of currents I_{in} flowing into that node is equal to the sum of currents I_{out} flowing out of that node. It can be written as,

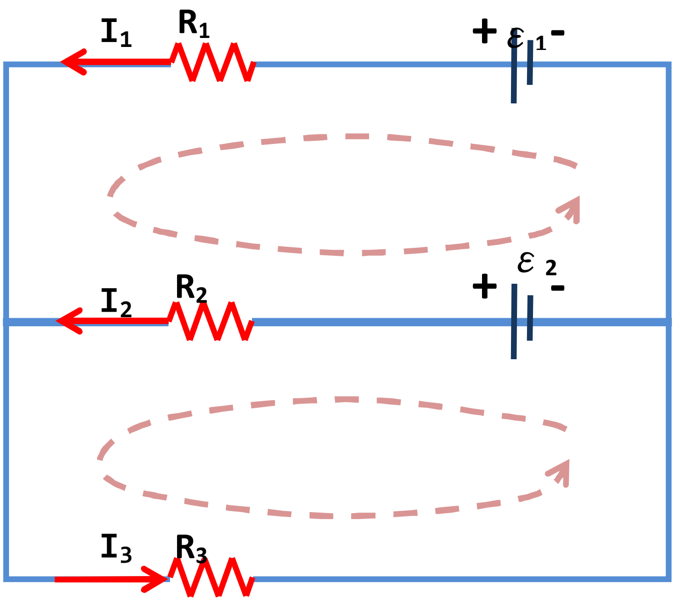
$$\sum I_{in} = \sum I_{out}$$

It's also known as node rule, ΣI=0
Kirchhoff's voltage law (KVL): the directed sum of the electrical potential differences (voltage) around any closed network is zero. It can be written as,

$$\sum \Delta V = 0$$

Loop rule, Σε-ΣIR = 0. (ε: EMF)

- **Dual power circuit :**



Dual power circuit

Using the loop rule according to the above figure:

$$I_1R_1 - I_2R_2 = -\varepsilon_2+\varepsilon_1 \quad (1)$$

$$I_2R_2 + I_3R_3 = \varepsilon_2 \quad (2)$$

According to the node rule:

$$I_3 - I_1 - I_2 = 0 \quad (3)$$

Calculate the above equations, we can obtain:

$$I_1 = \frac{\varepsilon_1(R_2+R_3)-\varepsilon_2R_3}{R_1R_2+R_2R_3+R_3R_1}$$

$$I_2 = \frac{\varepsilon_2(R_1+R_3)-\varepsilon_1R_3}{R_1R_2+R_2R_3+R_3R_1}$$

$$I_3 = \frac{\varepsilon_1R_2+\varepsilon_2R_1}{R_1R_2+R_2R_3+R_3R_1}$$

- **Wheatstone bridge experiment**

According to Figure 3-3, we know that when no current flows through the galvanometer, which means the points B and E have the same potential, so $V_B = V_E$. Meanwhile, the potential difference between two points A and B is V_{AB}, which is equal to the potential difference V_{DE} of the points D and E. The potential difference V_{BC} between two points B and C equals the potential difference V_{EF} of the points E and F.

We obtain,

$$V_{AB} = V_{DE}$$

$$V_{BC} = V_{EF}$$

Assuming the current through R_1 is i_1, and the current through R_3 is i2,

$$i_1 R_1 = i_2 R_3$$

$$i_1 R_3 = i_2 R_4$$

So

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

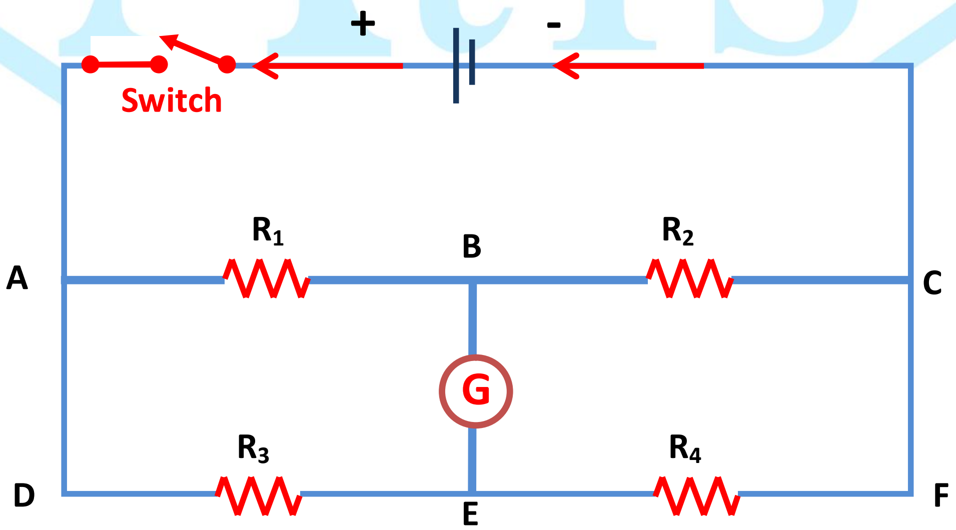


Fig. 3-3 Wheatstone bridge

The Wheatstone bridge method can be used to measure wires of different length or thickness, such as copper or nickel-chromium wire. As shown in Figure 3-4, A and B are metal wires, R_s is a standard resistor, R_X is a measurable resistance. When the reading of the galvanometer is zero, which means the bridge is balanced.

$$\frac{R_X}{R_S} = \frac{L_2}{L_1} \quad \text{or} \quad R_X = (\frac{L_2}{L_1})R_S$$

Use the formula to calculate the unknown resistance value using the Wheatstone bridge method.

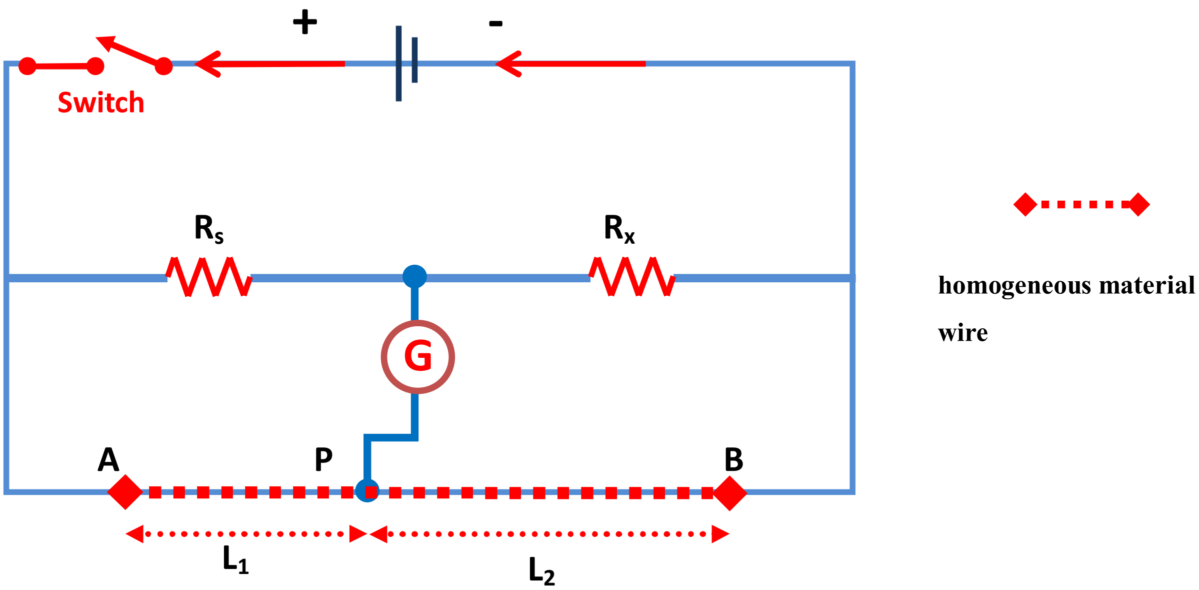
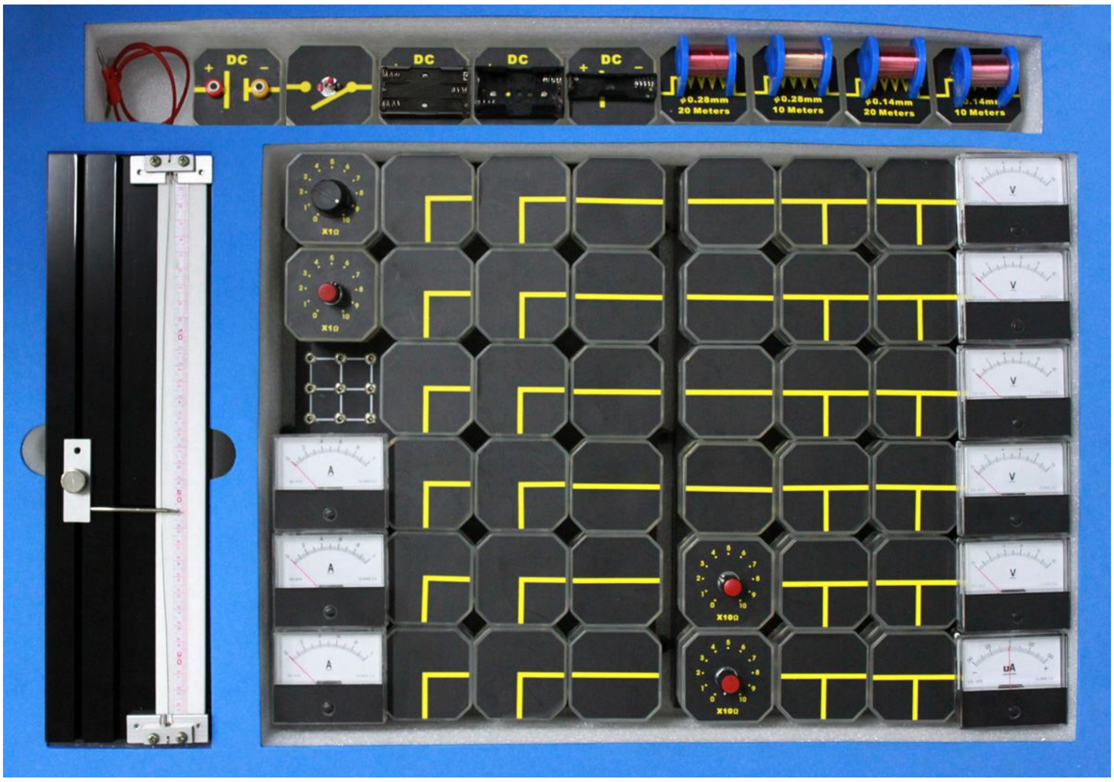


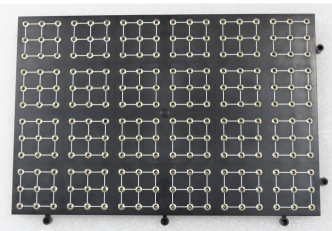
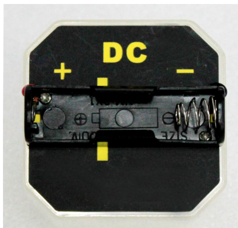
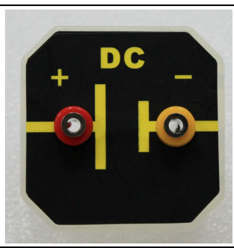
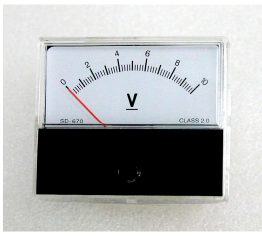
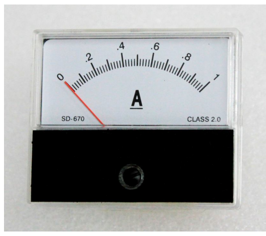
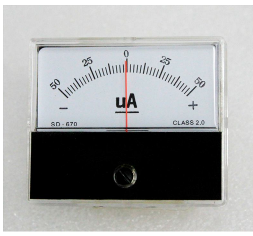
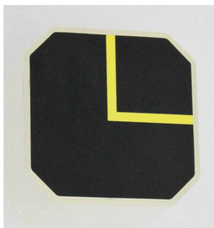
Fig. 3-4 Wheatstone bridge

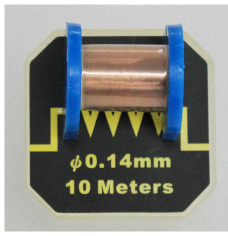
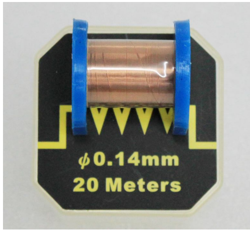
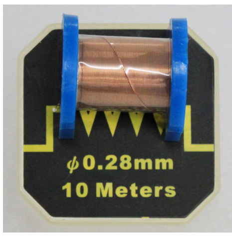
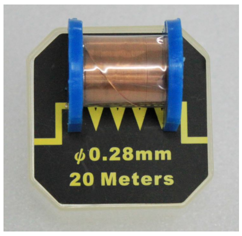
Instrument

NO	Accessory	Quantity
1.	Bread Board	2
2.	Circuit Switch	1
3.	Single Battery Seat	1
4.	Dual Battery Seat	1
5.	Triple Battery Seat	1
6.	DC Port	1
7.	Voltmeter	5
8.	Ammeter	3
9.	Galvanometer	1
10.	I-shaped Line	11
11.	T-shaped Line	12
12.	L-shaped Line	12
13.	Slide Wire Bridge	1
14.	10Ω Resistor	2
15.	1Ω Resistor	2
16.	Measurable Resistor - a	1
17.	Measurable Resistor - b	1
18.	Measurable Resistor - c	1
19.	Measurable Resistor - d	1
20.	Connecting Wire	1

Accessories

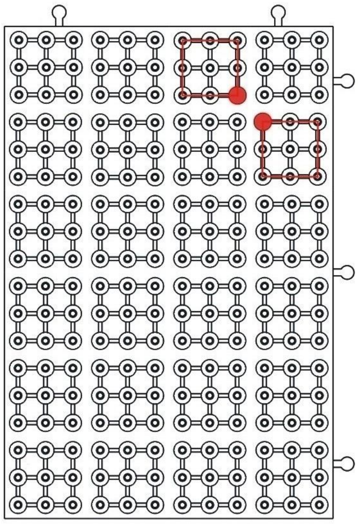


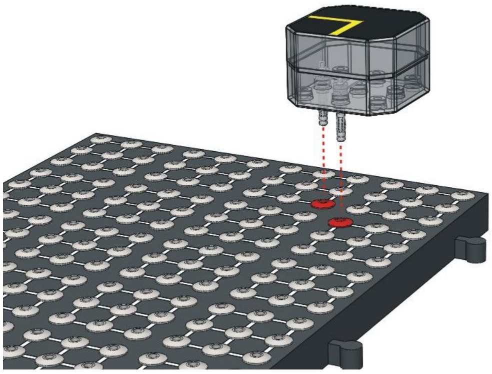
			
1	2	3	4
			
5	6	7	8
			
9	10	11	12

			
13	14	15	16
			
17	18	19	

Procedure

When connecting the circuit, be aware of the relative position of the metal hole and the circuit elements. The circuit elements must be connected in between two squares as shown in the figure below.





Notice

1. Do not insert and remove the electronic components too hard in order to avoid the damage of breadboard contacts.

2. Please contact us if the components are damaged. Do not change the components by yourself.

- **Ohm's law**

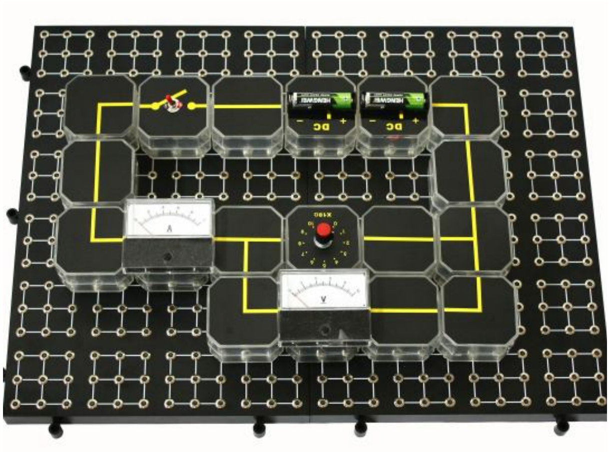


Fig. 5 Ohm's law

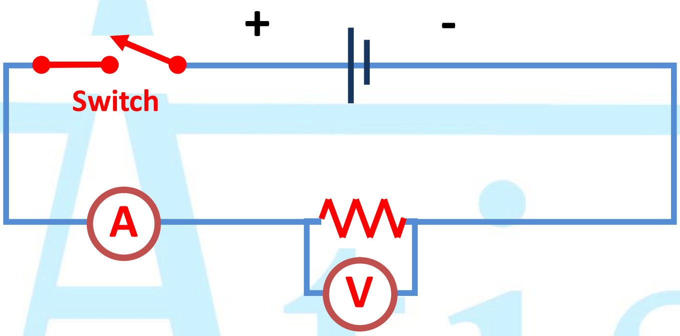


Fig. 6 Circuit of Ohm's law

1. The experimental apparatus as shown in Fig. 5 and 6 above. Connect the ammeter in series, but connect the voltmeter and the resistor in parallel. Then set up the battery and the power supply, and then adjust the resistance value.

2. According to the record sheet (1), record the values of the supplied voltage and the resistor. Use Ohm's law to calculate the current value.

3. Record the values of the ammeter and voltmeter, comparing the calculated values with the measured values. Draw a relationship diagram.

4. Change the resistor values to repeat step 2 and 3.

5. Change the fixed resistor value to repeat step 2, 3 and 4 and record the values down on the record sheet (2)...

- **Kirchhoff's law**

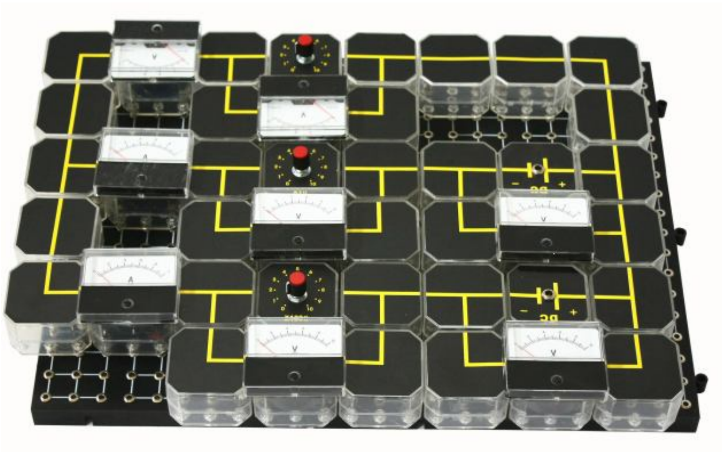


Fig. 7 Kirchhoff's law

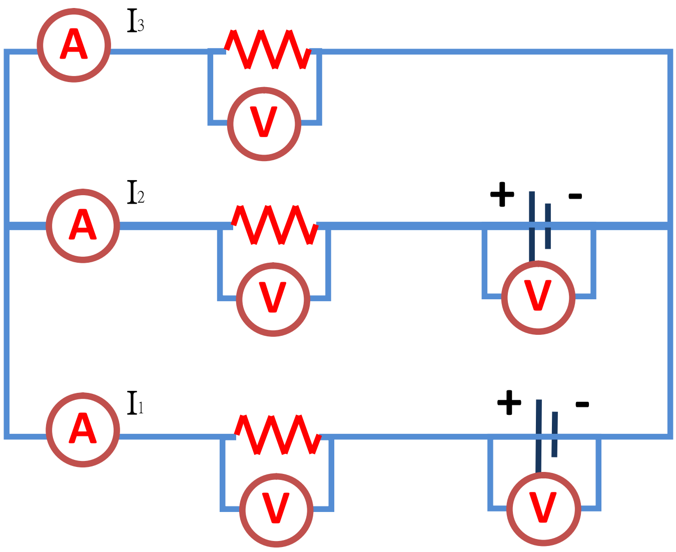


Fig. 8 Circuit of Kirchhoff's law

6. The experimental apparatus as shown in Fig. 7 and 8 above. Connect the ammeter in series, but connect the voltmeter and the resistor in parallel. Then set up the battery and the power supply, and then adjust the resistance value.

7. According to the record sheet (2), record the values of the supplied voltage and the resistor. Use Kirchhoff's law to calculate the current value I_1 , I_2, and I_3.

8. Record the values of the ammeter and voltmeter, comparing the calculated values with the measured values.

9. Change the resistor values to repeat step 7 and 8.
10. Change the voltage value to repeat step 7, 8 and 9.

- **Wheatstone bridge**

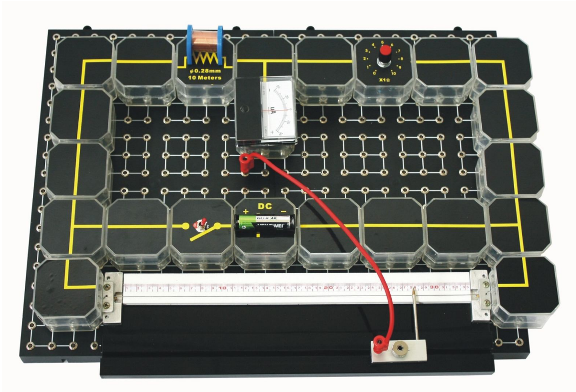


Fig. 9 Wheatstone bridge

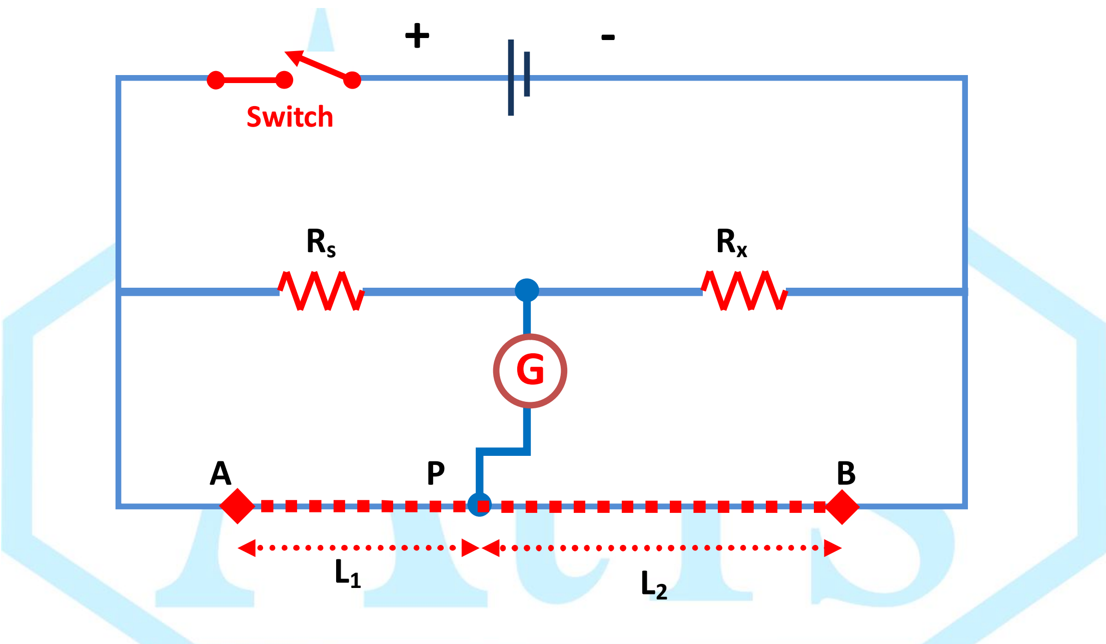


Fig. 10 Circuit of Wheatstone bridge

11. The experimental apparatus as shown in Fig. 9 and 10 above. Then set up the battery, the power supply and the wire

12. According to the record sheet (2), record the values of the supplied voltage and the resistor. And then move the probe to make the galvanometer reading back to zero. According to the theory to calculate the values of measurable resistors.

13. Compare the calculated values with the measured values.

14. Change the resistor values to repeat step 12 and 13.

15. Change the voltage value to repeat step 12, 13 and 14.

Experimental Record

Record Sheet (1)				
Voltage value	Resistor value	Current value	Ammeter measured value	Voltmeter measured value

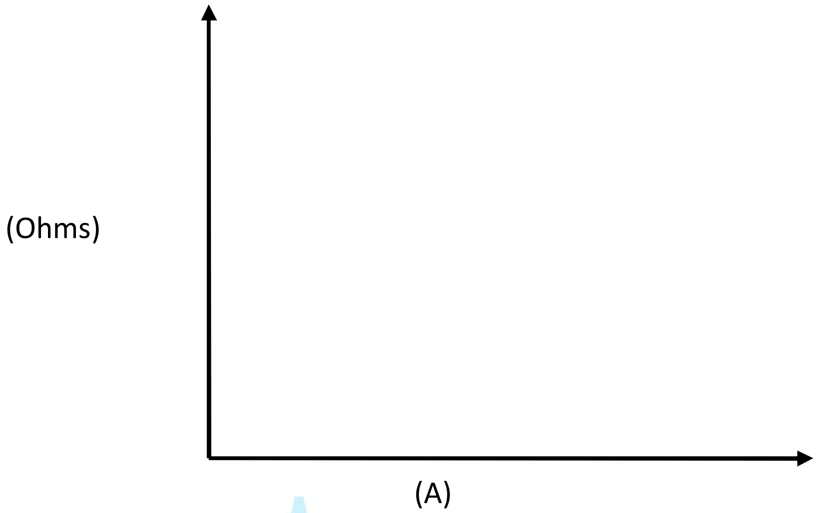
Record Sheet (2)				
Voltage value	Resistor value	Current value	Ammeter measured value	Voltmeter measured value

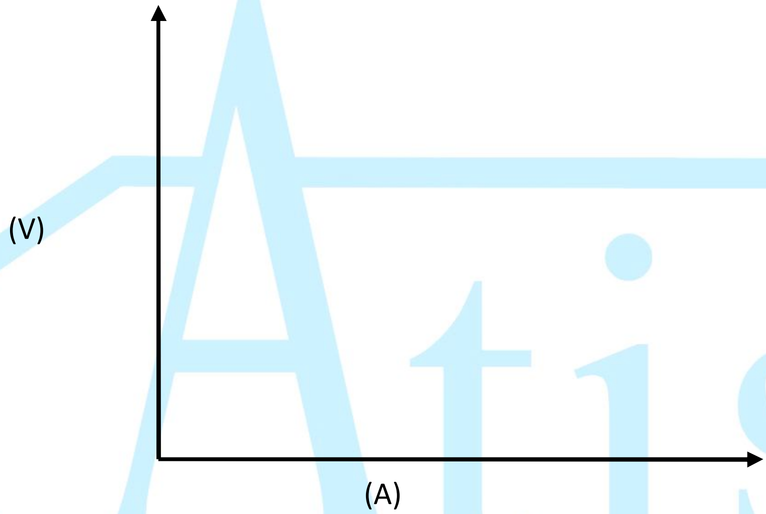
Record Sheet (3)					
Trial	1	2	3	4	5
ε_1					
ε_2					
R_1					
R_2					
R_3					
I_1					
I_2					
I_3					
ε_1					
ε_2					
I_1					
I_2					
I_3					

Record Sheet (4)				
E	R_S	L_1	L_2	R_X

Questions and Discussions

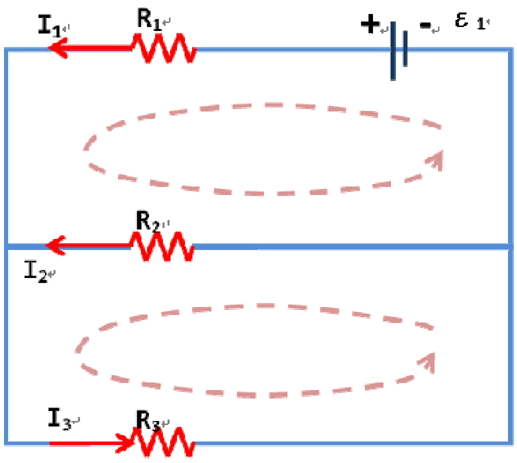
1. According to the record sheet (1) and (2), draw a diagram showing the relationship.





2. Change the dual power circuit to a single-supply circuit, try to describe the current values I_1, I_2 and I_3.

3. Describe the Wheatstone bridge theory



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