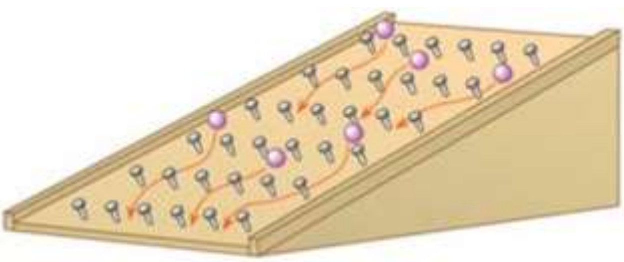
Resistance According to the Length and Cross-Sectional Area of Pencil Leads

1. **Measuring the current and voltage according to the changes in the length and cross-sectional area of pencil leads.**
2. **Using the measured current and voltage to calculate resistance, and explaining the relationship between length and resistance, and between cross-sectional area and resistance.**

Fundamental Concept

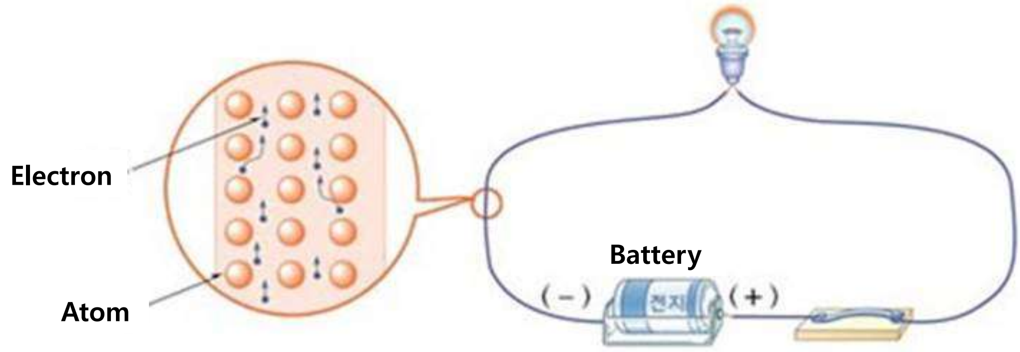
1. Electrical Resistance of a Conductor

(1) Electrical resistance of a conductor: If the electrical resistance of a conductor is different, even if the same voltage is applied to the conductor, the current flowing through it will differ. In other words, a conductor with high resistance will have weak current flow, and a conductor with low resistance will have strong current flow. Thus, electrical resistance obstructs the flow of current.



[Steel Ball Rolling Down an Inclined Plane]

(2) Cause: When a voltage is applied to a conductor, the atoms do not move, but the free electrons with a negative charge do. As electrons move through the metal, they frequently collide with the densely packed atoms, which obstructs their movement in a specific direction. Thus, the collisions between electrons and atoms cause the metal conductor to exhibit resistance.

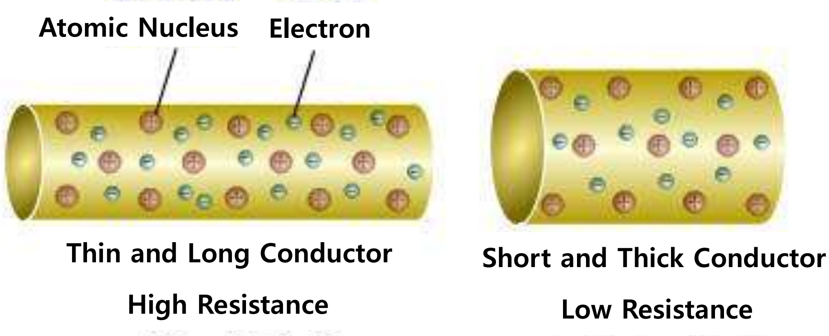


[Flow of Electrons in a Conductor]

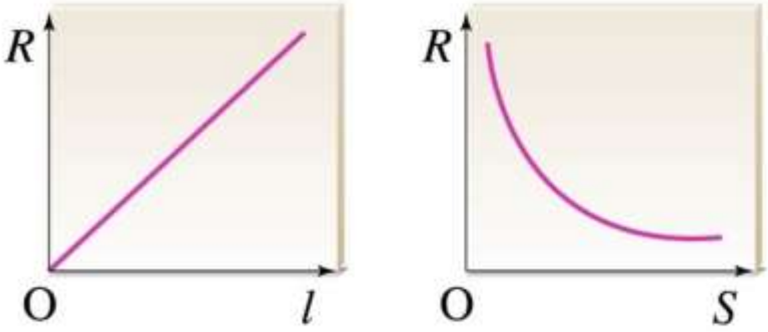
2. Length and Cross-Sectional Area of a Conductor and Electrical Resistance

(1) Length of a conductor and resistance: Generally, the resistance of a nichrome wire with the same type and thickness is proportional to its length. In other words, if the length of a metal conductor is doubled or tripled, its resistance will also double or triple.

(2) Cross-sectional area of a conductor and resistance: Generally, when the type and length of a nichrome wire are the same, its resistance R is inversely proportional to its cross-sectional area. In other words, if the cross-sectional area of the conductor is doubled or tripled, its resistance will be halved or reduced to a third.



(3) Length, cross-sectional area, and resistance of a conductor: The electrical resistance R of the same type of metal conductor is proportional to its length l and inversely proportional to its cross-sectional area S.



$$R = \rho \times \frac{l}{S}$$

(l: length of the conductor, S: cross-sectional area of the conductor, ρ: resistivity (a specific resistance value of the conductor))

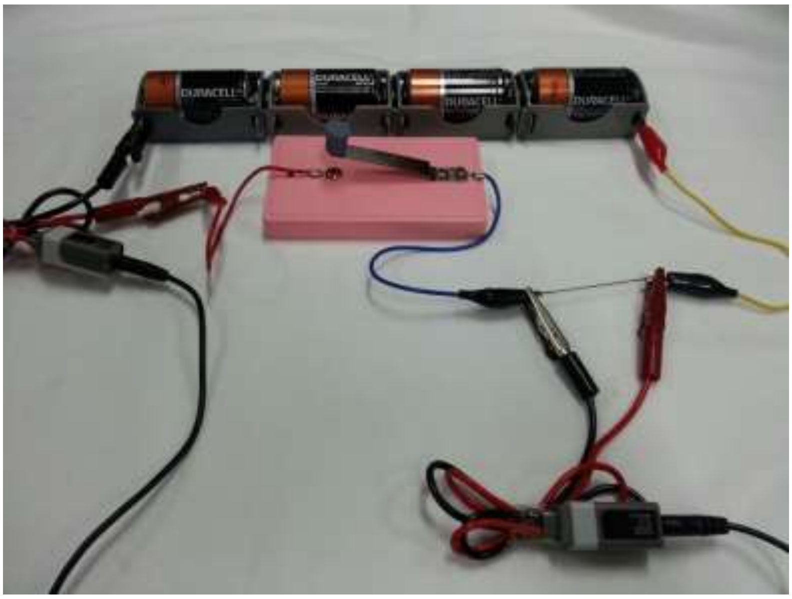
Experiment

Materials Needed

Interface, Science# program, Voltage sensor, Current sensor, 4 types of pencil leads (0.3/0.5/0.7/0.9 based on thickness), Switch, 2 alligator clip wires, 4 battery holders, 4 batteries

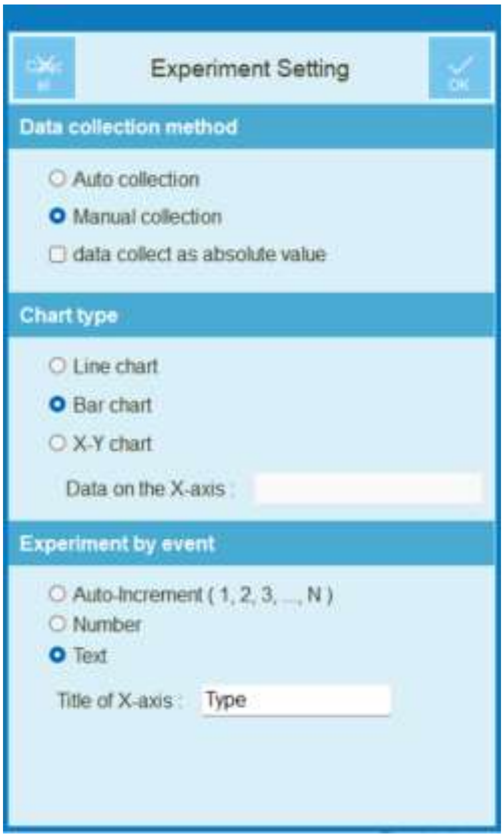
Experimental Setup

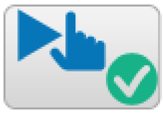
1. Choose a medium-thickness pencil lead and cut it into lengths of 2 cm, 4 cm, and 6 cm.
2. Connect the 2 cm pencil lead to the voltage sensor, current sensor, and switch to the battery to form a closed electrical circuit. (The voltage sensor should be connected in parallel with the pencil lead, and the current sensor should be connected in series.)



Interface Setup

1. Run Science#.
2. Connect the voltage sensor and current sensor to the interface.
3. Press the button to set up the experimental environment as shown below or press the button for automatic setup..





Data Collection

[Measuring Voltage and Current According to Length]

1. Press the button and then press the switch to complete the closed circuit. Measure the voltage and current for the 2 cm pencil lead.,
2. Increase the length of the pencil lead to 4 cm and 6 cm, and measure the voltage and current for each length.
3. Press the button to end the experiment..

[Measuring Voltage and Current According to Cross-Sectional Area]

4. Using the same method, change the cross-sectional area of the pencil lead and measure the voltage and current for each pencil lead.

Caution! Do not touch the pencil lead directly while current is flowing through it as it generates heat.

Data Analysis

Recording Data

1. Display the changes in current and voltage according to the length of the pencil lead in a bar graph, and calculate the resistance for each length using the table below.

   [Graph]

[Table]

Length (cm)	Voltage (V)	Current (A)	Resistance (Ω)

2. Display the changes in current and voltage according to the cross-sectional area of the pencil lead in a bar graph, and calculate the resistance for each area using the table below.

   [Graph]

[Table]

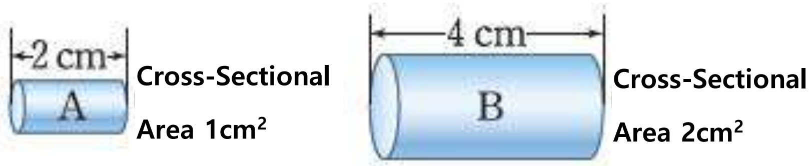
Cross-Sectional Area	Voltage (V)	Current (A)	Resistance (Ω)

Data Application

1. Summarize the relationship between the length of the pencil lead and its resistance based on the experimental results.

2. Summarize the relationship between the cross-sectional area of the pencil lead and its resistance based on the experimental results.

3. In the diagram below, the resistance of conductor A, which has a length of 2 cm and a cross-sectional area of 1 cm^2, is 10Ω.



Calculate the resistance of conductor B, which is made of the same material as conductor A but has twice the length and twice the cross-sectional area.