

Ohm's Law

Purpose

Using Arduino micro-controllers with "Lab in Your Pocket" app as current and voltage sensors to investigate the relation $V = IR$ and find the resistance of resistor.

Theory

- Ohm's Law states that the current (I) flowing through a conductor is directly proportional to the voltage (V) across it. The proportionality is defined as resistance (R).
- Resistance of an object describes the difficulty of driving the charge to move in it, i.e. the current flow. According to the relation $I = \frac{V}{R}$, ones have to apply higher voltage in order to generate the same current flow on an object with higher resistance.
- Current I is a vector that gives direction of current flow, while voltage V is a scalar that gives relative difference between "high" and "low" of potential. Free electrons in conductor tend to flow from high potential to low potential, generating current.
- The SI unit of voltage is Volt (V). The SI unit of current is Ampere (A). The SI unit of resistance is Ohm (Ω). The Arduino current sensor takes the current in the unit of milliampere (mA).
- The voltage sensor is assumed to have infinitely large resistance such that it does not affect the **equivalent resistance** ($\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$) of the circuit. ($\frac{1}{R_i} \rightarrow 0$ as $R_i \rightarrow \infty$)
- Note that the current distribution across a parallel circuit is inversely proportional to the resistance of the branch, i.e. $I_i \propto \frac{1}{R_i}$. In other words, the voltage sensor does not draw any current from the resistor when connected **in parallel**. ($I_i \rightarrow 0$ as $R_i \rightarrow \infty$) (Fig 1)
- The current sensor is assumed to have zero resistance such that it does not alter the equivalent resistance of the circuit. Note: Resistance adds up directly in series connection.
- A resistor must be included in the circuit to prevent short circuit. The current should not exceed 1000mA so as to avoid circuit overheat.
- The "Lab in Your Pocket" app connects with the Arduino sensors to measure the voltage across a circuit and its current.

Apparatus

- A power bank or D.C. electricity supply with appropriate voltage
- A mobile device with "Lab in Your Pocket" app
- An Arduino current sensor and an Arduino voltage sensor (provided by PolyU)
- A (variable) resistor

Setup

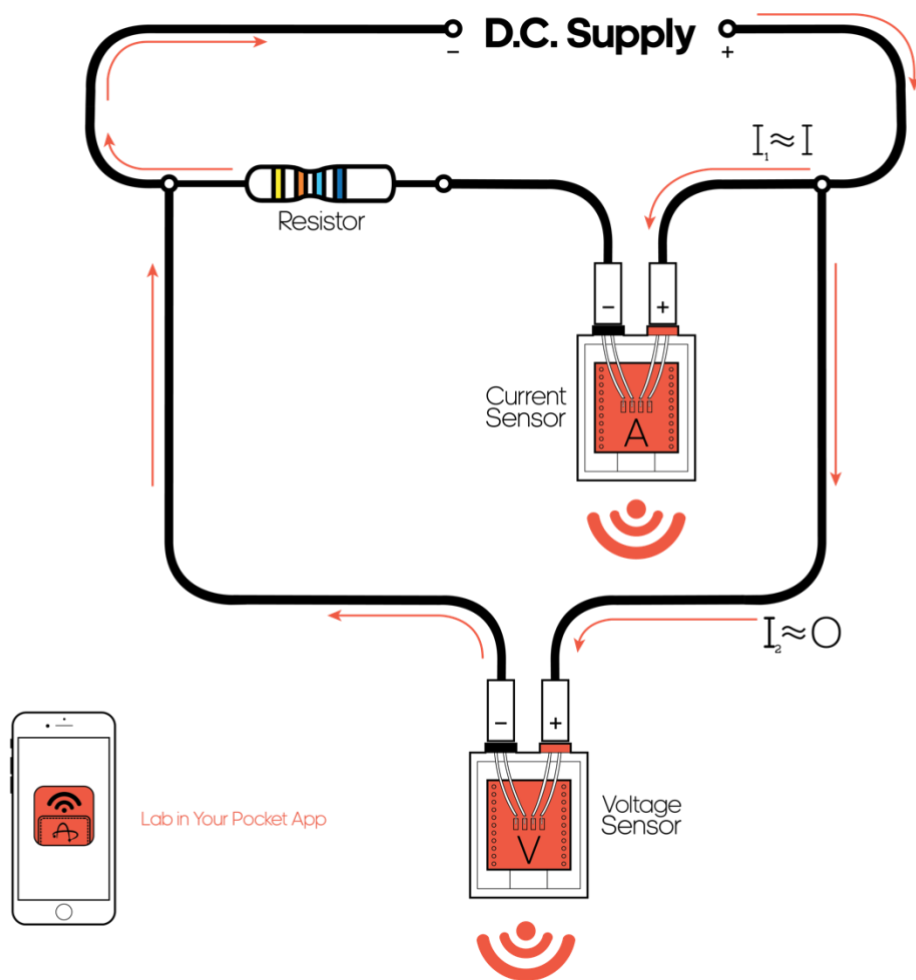


Fig 1

Precautions

1. The current through current sensor and solenoid shall not exceed 1000mA (i.e. 1A) to avoid overheat or damage of the components.

Assumptions

1. Voltage sensor consists infinite resistance such that it does not affect the equivalent resistance and draws no current.
2. Current sensor consists zero resistance such that it does not affect the equivalent resistance.

Procedure

Set up the Experiment

1. Set up the circuit as shown in Fig 1.
2. Connect the Arduino current sensor and voltage sensor to a 5V power supply respectively.



Fig 2

3. Open “Lab in Your Pocket” app in the mobile device and choose “Ohm’s Law” (Fig 2).
4. Register the Arduino sensors with the address printed on the sensors (Fig 3). Press “Connect” to connect the sensors (Fig 4). When the connection finishes, the app will automatically jump into a real-time graph of the voltage in V and current in mA.



Fig 4



Fig 3

5. Observe the background noise and error from both sensors before turning on the D.C. supply.
6. Press “Set Zero” button on the app interface to remove offsets.

Testing the Resistor

7. Turn on the D.C. power supply with the lowest voltage.
8. Record the instantaneous voltage and current values by pressing the “Record” button at the bottom-right corner (number of recorded data point is stated above).

- Repeat Step 8 with increasing current by changing the voltage supply, e.g. 100mA interval, until it reaches 1000mA (to prevent current overflow that may cause sensor damage).

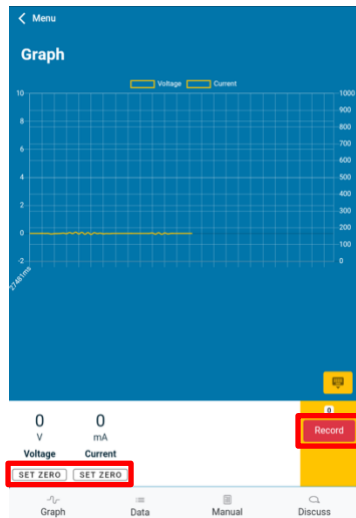


Fig 5

- Press “Record” tab and record the data (Fig 6). Plot the graph in the data sheet and find the relationship between voltage and current. Find the resistance R using the slope of the graph.

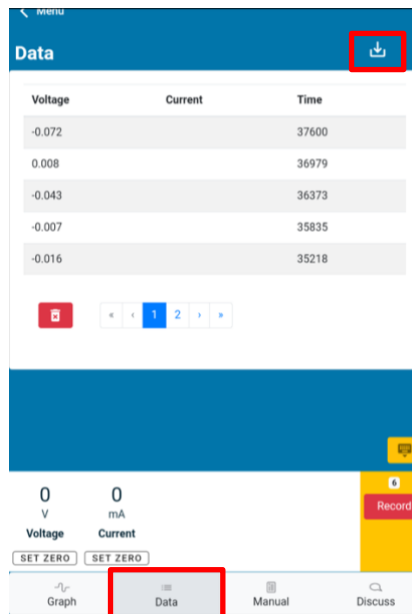


Fig 6

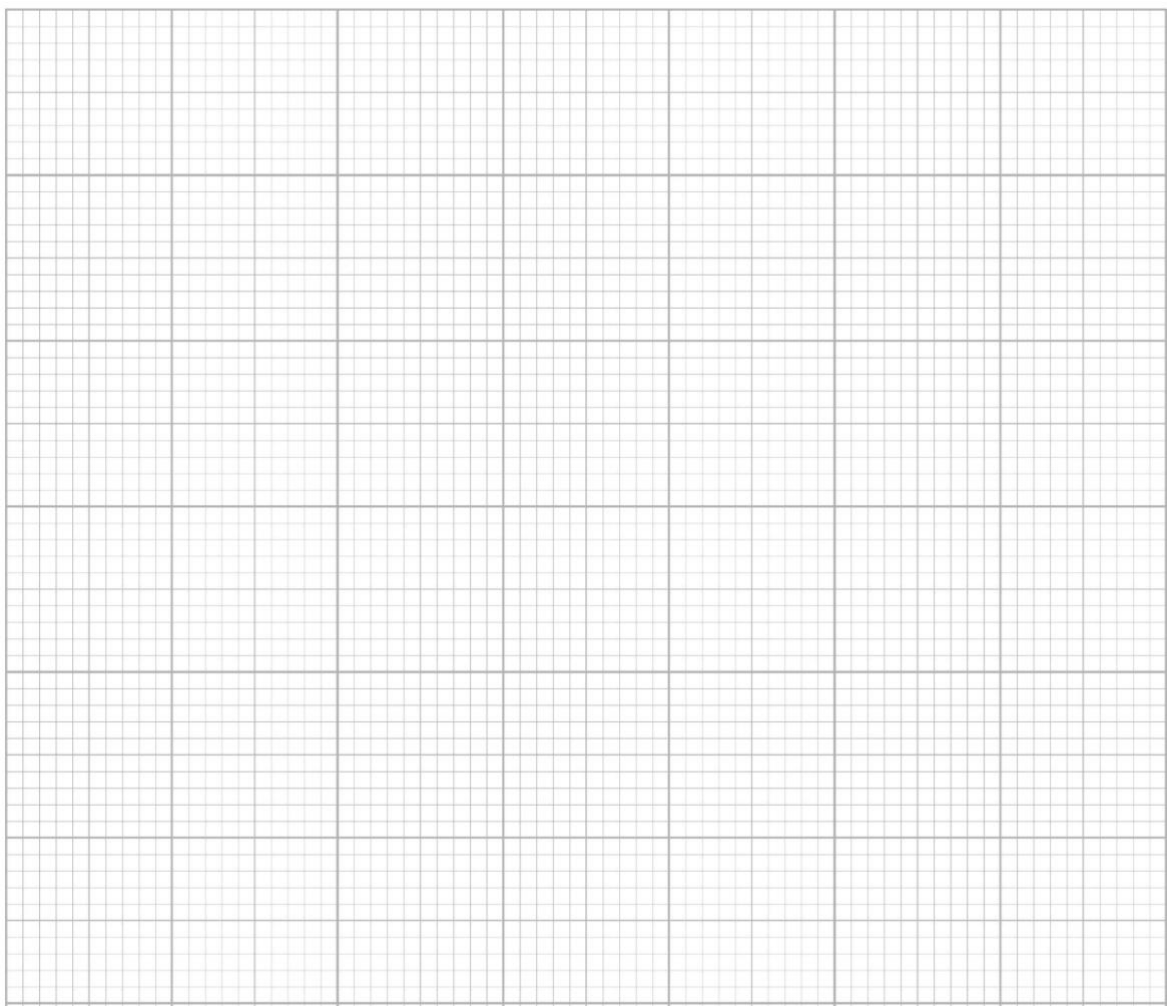
- Optional: Repeat the experiment with more than one resistor connected in series, and in parallel, to find the equivalent resistance when resistors are connected in different ways.

Data

Current across Resistor with Different Voltage

Voltage V (V)	Current I (A)

Plot a graph of current I against the voltage V .



Slope of Graph = Resistance $R =$ _____ Ω

Discussion

1. What are the sources of background voltage and current? Are they significant to the experiment?
2. What is the relationship of the current I against voltage V ?
3. From the slope of the graphs above, you can determine the experimental value of the resistance R . What is the value? Compare your experimental value with the known value.
4. What are the possible errors of the experiment? How can we improve to reduce the errors?