Electric Circuit

~ Series Circuit~

NaRiKa Corporation

1. Learning Outcomes

Learners will learn about the relationship between current, voltage, and resistance through electricity experiments. Learning outcomes of this experiments for learners are to assemble a series circuit and to acquire the skill to correctly measure current and voltage of electricity flowing in the circuits with meters.

2. Introduction of Equipment for Experiments

DC ammeter and DC voltmeter are required for this experiment. Caution is needed when connecting conventional DC ammeter or DC voltmeter to the electric circuit because these types of meters will be damaged unless connected to a terminal with proper measurement range. Multimeter can be misleading equipment for learners, too, because they tend to waste much time in unrelated measurement due to the multi-functions. In the following experiment, user friendly miniature digital DC ammeter and digital DC voltmeter with a single function will be used, so that learners can do various experiments in a short time.

A05-7060 Miniature DC Ammeter

- Measurement range: ±3A
- Automatically switchable display: 1mA (0~±500mA)
  0.01A (~±3.0A)
- Size: 53 × 21 × 15mm、Whole length: ca 280mm
- Battery: CR1220 x 1pc

A05-7065 Miniature DC Voltmeter

- Measurement range: ±25V
- Automatically switchable display: 0.01V (0~±5.00V)
  0.1V (±5.1V~±25.0V)
- Size (body): 53×21×15mm, Whole length: ca280mm
- Battery: CR1220 x 1pc

With these miniature meters, learners are no longer required to spend their time for the troublesome measurement range selection as happens with multimeters. These meters are suitable for learners' experiments due to the following functions, such as automatic measurement range change and built-in protection circuit for overload prevention. Furthermore, learners can view the meters as a part of an electric circuit because they are small enough when compared with conventional ones.

3. Experiment of Series circuit

1. Purpose of this experiment:

Learners will learn to assemble a series electric circuit by combining a dry cell battery (power source), a miniature incandescent bulb (resistance), and a switch. They will also acquire the skill of measuring current and voltage using the digital miniature meters properly.

2. What to prepare:

- A05-7060 Miniature DC Ammeter CT-A x 1
- A05-7065 Miniature DC Voltmeter CT-V x 1
- B10-6254-1 Knife Switch (hereinafter "Switch") x 1
- B10-6413 Base for miniature bulb x 2
- P70-0366-11 Miniature bulb (3.8V, 0.3A) x 2
- P70-0720-03 Dry cell battery (AA type) x 2
- P70-0342 Dry cell battery holder x 2
- B10-6503 Lead wire with clips (red & black) x 2 pairs

3. Procedure for Experiment

1. Let us assemble a series electricity circuit with two miniature bulbs.

1) Assemble a series circuit using two miniature bulbs, two dry cells batteries, and a switch as shown in Fig. 1 below.

2) Test the series circuit whether the bulbs will light up or not when closing the switch.

Caution: If the bulbs will not light up, check each of the connections to the base for miniature bulb. In case one or both of the bulbs are securely screwed in but will not light up, change the bulb(s) to a new one(s) and/or change the dry cell battery to a new one.

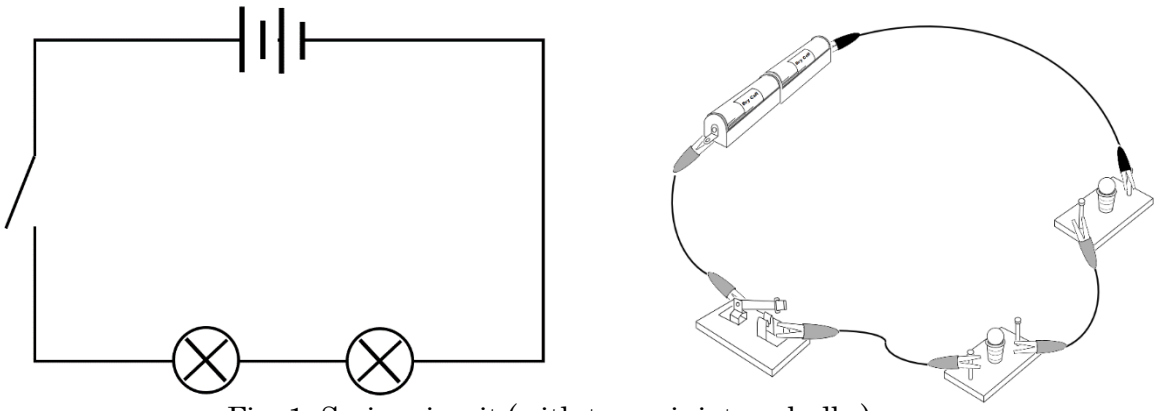

Fig. 1. Series circuit (with two miniature bulbs)

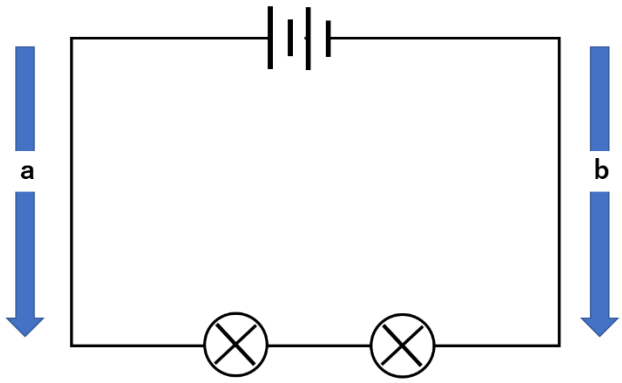

Fig. 2. Direction of electric current in series circuit

2. Let us measure the electric current flowing in the series circuit.

1) Predict direction of electric current that flows in the circuit shown in Fig. 1. Which direction, (a) or (b) as shown in Fig. 2, does the electric current flow in that circuit?

2) Connect an ammeter with each of the positions A1 - A3 in the series circuit shown in Fig. 3 and fill the measurement values in Table 1 below.

> **Caution:** When connecting a meter, confirm the polarity of the circuit. The Red clip of lead from the meter should be connected to the positive (+) side and the black clip should be connected to the negative (-) side of the circuit.

3) According to the Table 1, which direction (a or b shown in Fig. 2) do you think the current flows in the circuit?

4) Remove one miniature bulb from the series circuit and assemble a simple circuit again (see Fig. 4).

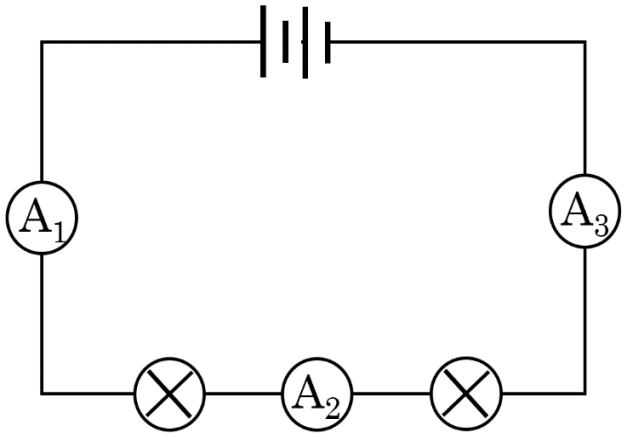

Fig. 3. Measurement current in the series circuit

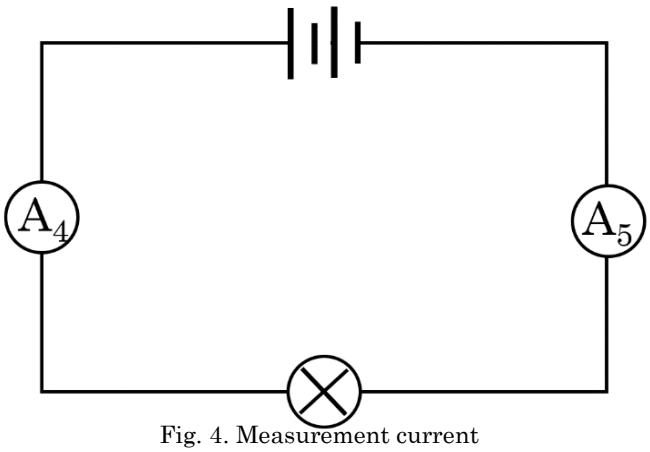

Fig. 4. Measurement current in the simple circuit

5) Connect the ammeter to each of the positions A4 and A5 in the circuit shown in Fig. 4 and fill those measurement values in Table 1 below.

Table1. Amperages in Fig.3 and Fig.4

Ammeter	Measured
A_1	0.2 A
A_2	0.2 A
A_3	0.2 A
A_4	0.3 A
A_5	0.3 A

6) Describe the relationship between electric current value and type of the circuit based on the result shown in Table 1.

There is no significant difference between electric current value of series circuit and simple circuit regardless of the number of miniature bulbs connected with each circuit.

Caution: This relationship can only be applied to when using bulbs with the same specifications.

Using bulbs with different specifications in the circuit will lead to different result from Table 1.

3. Let us measure the voltage in the series circuit.

1) Predict voltage values to be measured at each of V1 - V3 in the circuit shown in Fig. 5, given voltage of one dry cell is 1.5V, and fill your prediction in Table 2 below.

2) Measure voltage value at each of V1 - V3 shown in Fig. 5 and fill it in Table 2.

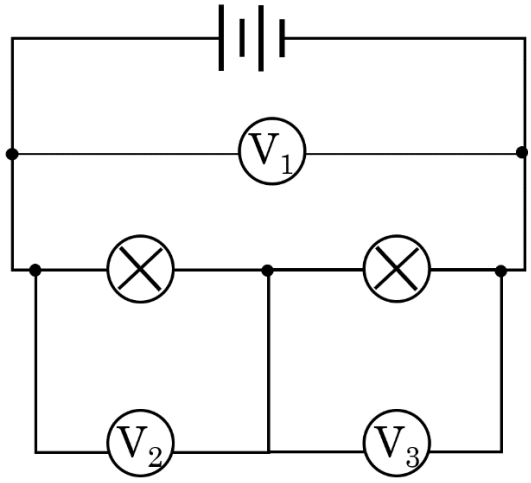

Fig. 5. Measuring potential difference (Voltage) in series circuit

Table2. Voltages in Fig.5

Voltmeter	Prediction	Measured
V_1	V	2.8 V
V_2	V	1.4 V
V_3	V	1.4 V

3) Remove one of the miniature bulbs from the series circuit and assemble a simple circuit again (see Fig. 6).

4) Measure voltage value at V4 shown in Fig. 6 and fill it in Table 3 below.

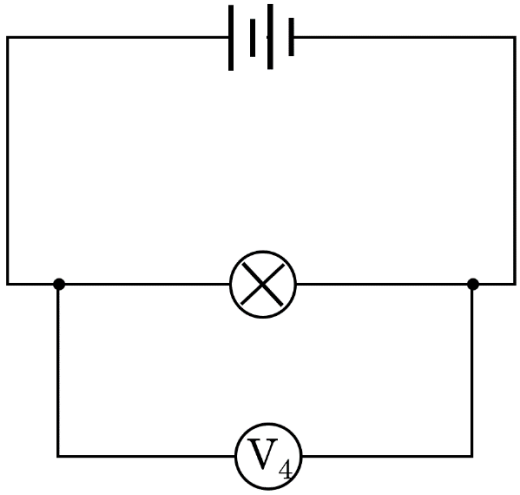

Fig. 6. Measuring potential difference (Voltage) in simple circuit

Table3. Voltages in Fig.6

Voltmeter	Prediction	Measured
V_4	V	2.4 V

5) Describe the relationship between the voltage and the circuit based on the result shown in Table 2 and 3.

Voltage values measured across the whole circuits (V1 and V4) are almost the same regardless of the number of bulbs connected with each circuit. In the case two bulbs are connected with a series circuit, each voltage value (V2 or V3) is half the value of that measured across the whole circuit.

4. Description

Through Experiment 1, learners learn that the components including two miniature bulbs, two dry cells batteries, and a switch constitute the series circuit by being connected to each other by lead wires. They also learn that there is a difference in the brightness of bulb(s) between the series circuit and the simple circuit through Experiments 2 and 3. In other words, they learn brightness of one bulb connected with simple circuit is brighter than each of two bulbs connected with series circuit.

Through Experiment 2, learners learn the amperage (current value) measured at any point (A1 - A3) in the series circuit is consistent, as well as, it is almost same as the amperage measured in the simple circuit shown in Fig. 4.

Through Experiment 3, learners learn the voltage values (V1 -V4) measured across two points before and after each bulb are not consistent between Fig. 5 and Fig. 6.

Fig. 7 and Fig. 8 below illustrate the circuit shown in Experiment 2 as an Electronic-hydraulic analogy because they show the same amount of water, as an analogy of electric current, flows at any given point of each path.

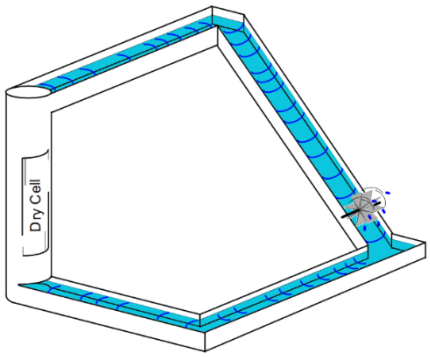

Fig. 7. Electronic-hydraulic analogy of the simple circuit 1

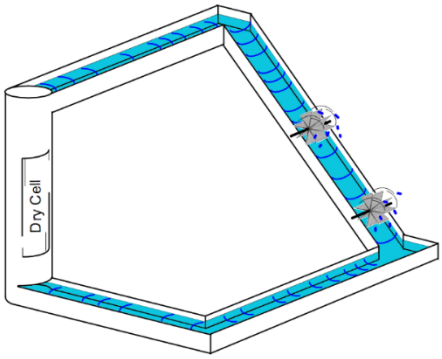

Fig. 8. Electronic-hydraulic analogy of the series circuit 1

Caution: However, specification of bulbs to be used for Experiment 2 must be the same, e.g. 3.8V, 0.3A. If specification of bulbs used for Experiment 2 varies, the result will be different from what was previously described. Different amperages would be measured in the series circuit if for example bulbs with specifications 3.8V, 0.3A and 2.5V, 0.3A are used concurrently. What causes this difference will be described in the later topics on Ohm's law.

Fig. 9 and Fig. 10 illustrate the circuit shown in Experiment 3 as an Electronic-hydraulic analogy. A dry cell plays a role as a pump in Fig. 9 and Fig. 10. Water, height up to the upper waterway and waterwheel are analogies for flowing electric current, electric potential difference, and miniature bulb(s) respectively. Height of the waterways are the same in Fig. 9 and Fig. 10 (the potential differences are the same). Difference in brightness of bulbs used in Experiment 3 is caused by the difference in number of waterwheels (bulbs) connected in the "incline" between Fig. 9 and Fig. 10.

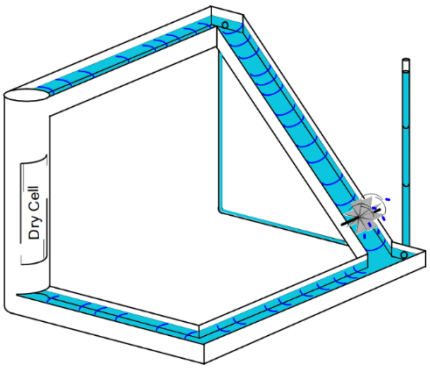

Fig. 9. Electronic-hydraulic analogy of the simple circuit 2

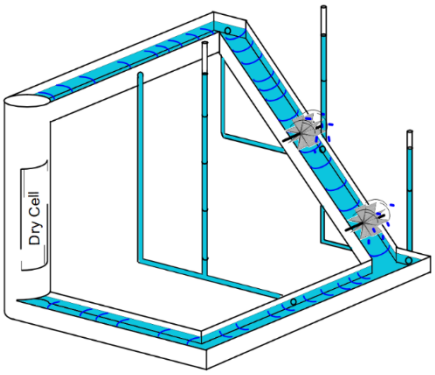

Fig. 10. Electronic-hydraulic analogy of the series circuit 2