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ENGS124 Electricity and Magnetism Lab Section B
Testing the Ohm's law with combinations of resistors

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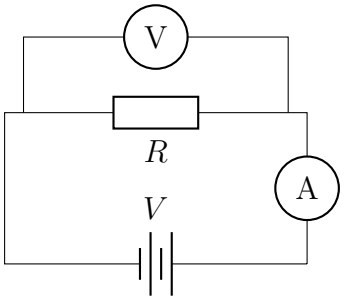
1 Introduction

The Ohm's law states that the current through a resistor is linearly proportional to the applied voltage and inversely proportional to the resistance.



$$I = \frac{V}{R}$$

Since voltage is the difference of electric potential between two points, we can clearly see that if we measure the voltages across two resistors in series, it must add up to the total voltage. Moreover, if we calculate the currents in those resistors, they will be the same, as the same charge passes through the circuit.

Now we have two parallel resistors. The current passing between the total circuit will be split between the resistors, because the charge cannot go through both resistors. Thus, the total current will be equal to the sum of the currents running through both resistors.

2 Measurements and data

Experiment 1. Voltage across the combination of resistors connected in series.
Two resistors, R_1, R_2 were connected in series. The circuit was connected to variable power supply.

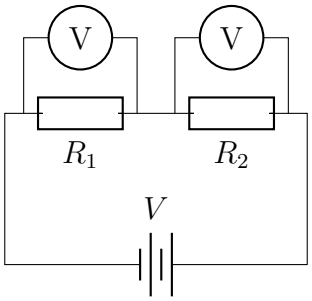


Figure 1: Experiment 1: Electric diagram

First, two resistors were measured, $R_1 = 5600\Omega$, $R_2 = 3230\Omega$. The power supply voltage was varied and the voltage across the resistors were measured with a multimeter.

V_{supply} (V)	R_1 (Ω)	R_2 (Ω)	V_1 (V)	V_2 (V)
10.04	5600	3230	6.28	3.74
8.00	5600	3230	5.01	2.98
6.00	5600	3230	3.75	2.23
4.00	5600	3230	2.51	1.49
2.00	5600	3230	1.25	0.74

Table 1: Experiment 1.1 data

Then, the power supply was kept at a constant $10V$, and different combination of resistors R_1 and R_2 were selected, and the voltages across them were measured with a multimeter.

V_{supply} (V)	R_1 (Ω)	R_2 (Ω)	V_1 (V)	V_2 (V)
10.04	5600	2100	7.21	2.82
10.04	3230	2100	6.05	3.97
10.04	5600	3230	6.28	3.74
10.04	2100	1390	5.90	4.13
10.04	3230	1490	6.88	3.15
10.04	5600	1490	7.88	2.16

Table 2: Experiment 1.2 data

Experiment 2. Ohm's Law.
Two resistors, R_1, R_2 were connected in series. The circuit was connected to variable power supply.

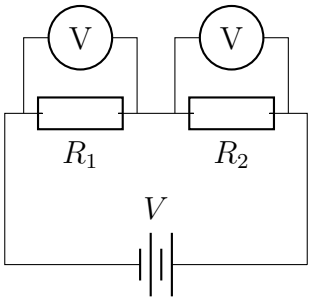


Figure 2: Experiment 2: Electric diagram

Various voltages were set on the power supply and various resistors R_1 and R_2 were selected, and the voltages across the resistors was measured.

V_{supply} (V)	R_1 (Ω)	R_2 (Ω)	V_1 (V)	V_2 (V)
10.00	5430	5000	5.20	4.78
9.00	6030	5000	4.92	4.07
8.00	5000	2130	5.62	2.4
7.00	5000	1480	5.40	1.59
6.00	3230	1490	3.61	2.37
5.00	3230	1490	2.89	2.10

Table 3: Experiment 2 data

Experiment 3. Testing the junction rule for parallel connection.
The following schematic was assembled, with three resistors and one variable power supply.

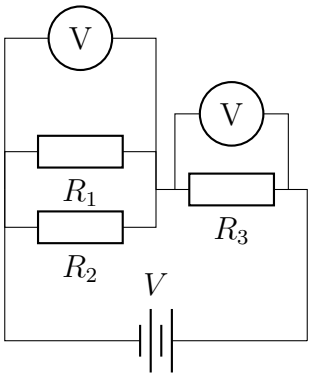


Figure 3: Experiment 3: Electric diagram

The power supply voltage was set a constant $15V$, the resistors were changed and the voltage across them was measured.

V_{supply} (V)	R_1 (Ω)	R_2 (Ω)	$(R_3$ (Ω)	$V_{1,2}$ (V)	V_3 (V)
15.00	3230	6060	4990	4.46	10.55
15.00	4990	2120	5400	3.24	11.76
15.00	5400	4990	2120	8.24	6.77
15.00	5400	2120	4990	3.51	11.50
15.00	6060	1470	3230	4.02	10.07
15.00	3230	1470	6060	2.14	12.86

Table 4: Experiment 3 data

Variable	Value	Resolution
Resistor resistances	Controlled	10Ω
Supply voltage	Controlled	$0.01V$
Voltages across resistors	Measured	$0.01V$

Table 5: List of variables

Instrument or material	Description
Multimeter	With resistance and voltage measure functionality
Lab bench power supply	With sufficient voltage range
Resistors	With different resistances
Cables	For the multimeter and power supply

Table 6: List of instruments and materials

Source of error	Type of error	Countermeasures
Power Supply Inaccuracy	Random	Since the voltage meter on the power supply is not very accurate, the voltage was also measured with a multimeter and tuned for improved accuracy.
Cable Resistance	Systematic	Higher values resistors were used, to reduce the significance of power supply and multimeter wire resistances in the measurements.
Resistor Heating	Systematic	With higher temperature, the resistance of a resistor increases. Higher resistances were chosen to limit the current passing through them and the heat generated from the current.

Table 7: Estimated errors

3 Calculations and plots

V_{supply} (V)	V_1 (V)	V_2 (V)	V_{total} (V)
10.04	6.28	3.74	10.02
8.00	5.01	2.98	7.99
6.00	3.75	2.23	5.98
4.00	2.51	1.49	4.00
2.00	1.25	0.74	1.99

Table 8: Experiment 1 calculations

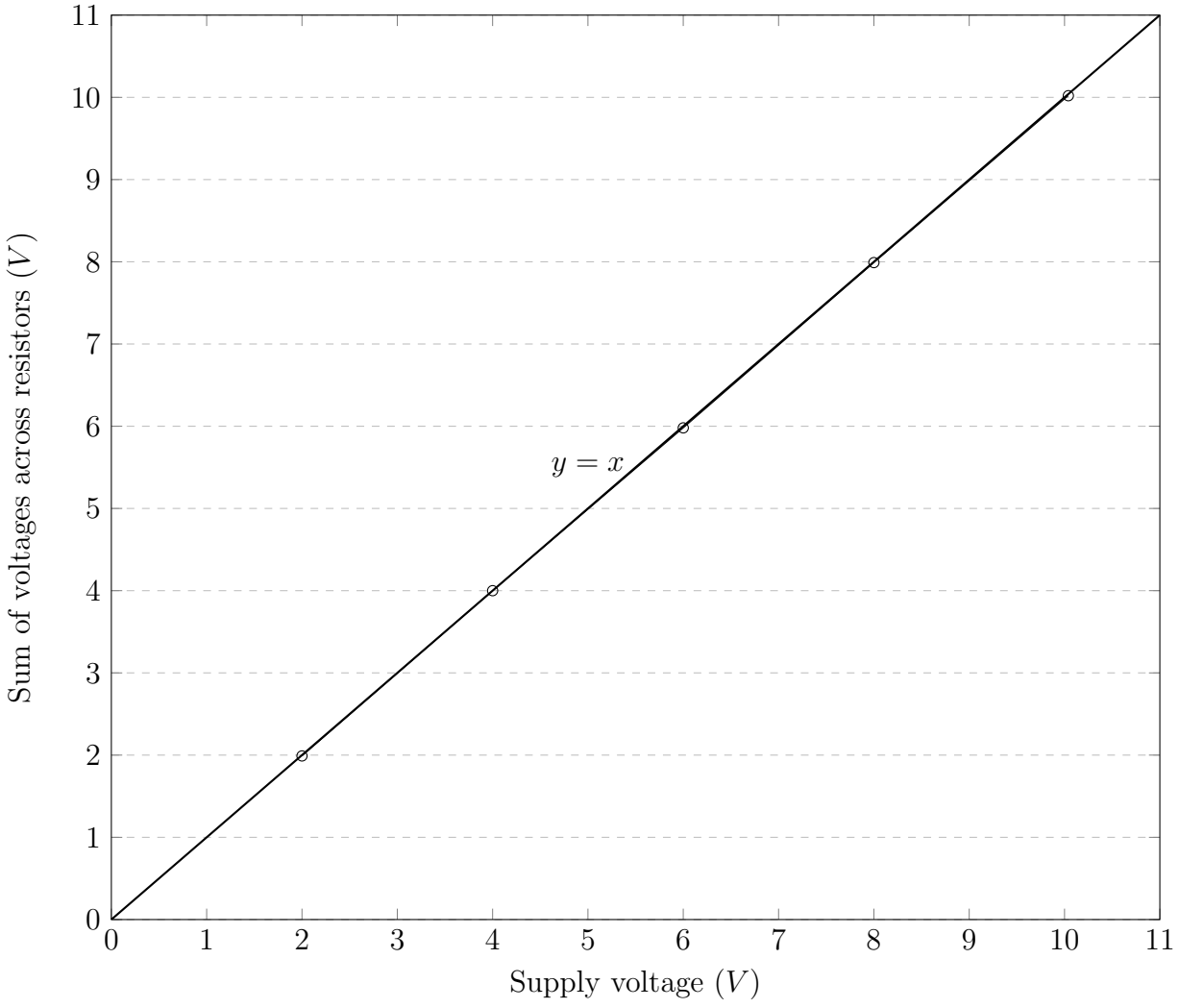


Figure 4: Plot of supply voltage and sum of voltages across resistors

$(R_1)\ \Omega$	$(R_2)\ \Omega$	$V_1\ (V)$	$V_2\ (V)$	$\frac{V_1}{R_1}\ (mA)$	$\frac{V_2}{R_2}\ (mA)$
5430	5000	5.20	4.78	0.96	0.96
6030	5000	4.92	4.07	0.82	0.81
5000	2130	5.62	2.4	1.13	1.13
5000	1480	5.40	1.59	1.08	1.07
3230	1490	3.61	2.37	1.12	1.11
3230	1490	2.89	2.10	0.89	0.89

Table 9: Experiment 2 calculations

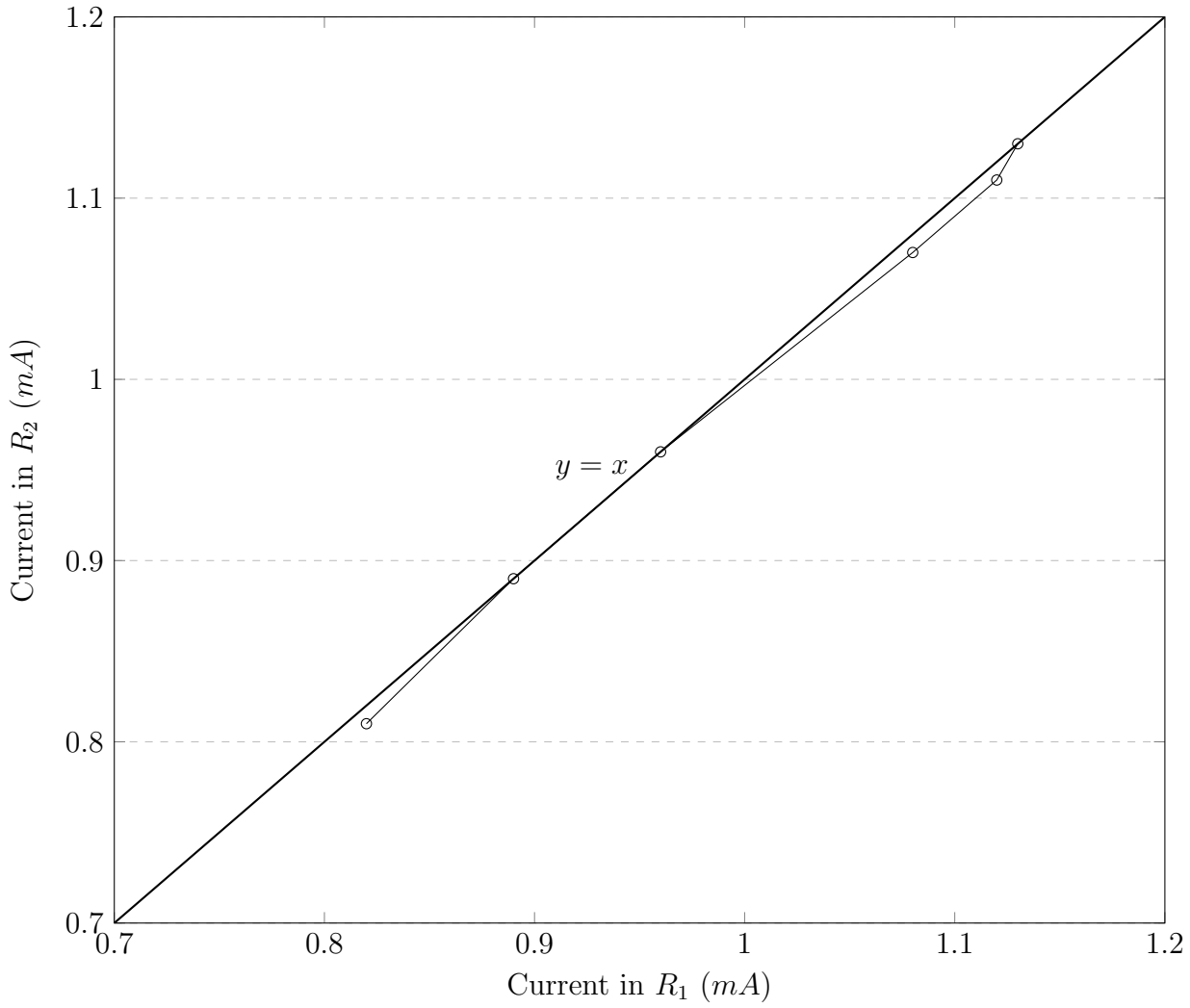


Figure 5: Plot of currents running through the resistors

R_1 (Ω)	R_2 (Ω)	$(R_3$ (Ω)	$V_{1,2}$ (V)	V_3 (V)	$\frac{V_1}{R_1} + \frac{V_2}{R_2}$ (mA)	$\frac{V_3}{R_3}$ (mA)
3230	6060	4990	4.46	10.55	2.12	2.11
4990	2120	5400	3.24	11.76	2.18	2.18
5400	4990	2120	8.24	6.77	3.18	3.19
5400	2120	4990	3.51	11.50	2.31	2.30
6060	1470	3230	4.02	10.97	3.40	3.40
3230	1470	6060	2.14	12.86	2.12	2.12

Table 10: Experiment 3 calculations

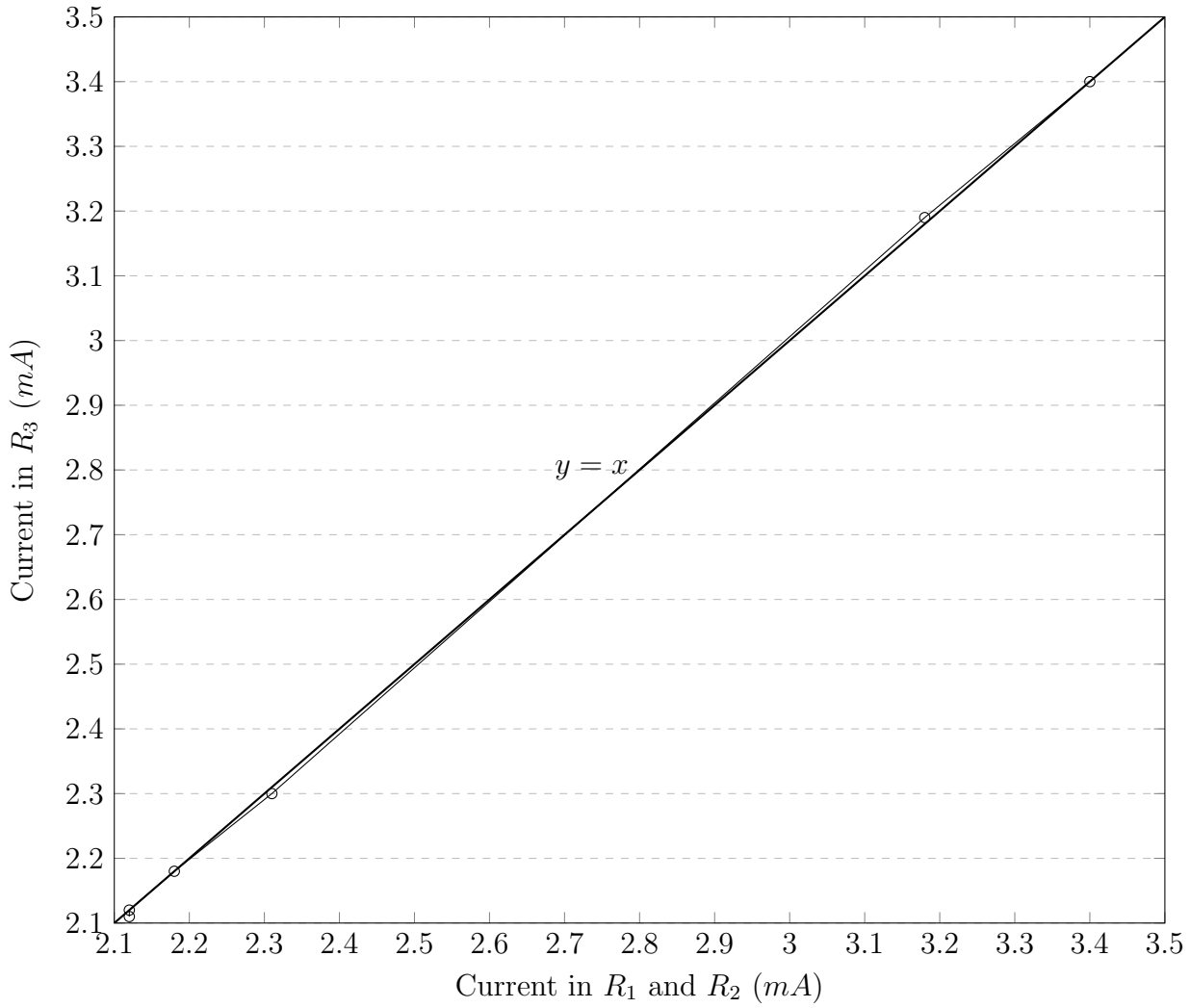


Figure 6: Plot of currents running through the resistors

4 Evaluation

The slope for all of the experiments was found to be 1. For the first experiment, the sum of the voltages across the resistors were equal to the supply voltage. For the second experiment, the current running through the first resistor was the same as the current running through the second resistor. For the third experiment, the current running through the third resistor was equal the the sum of the currents running through the first and second resistors.

5 Conclusion

Several experiments were carried out to test the validity of the Ohm's law and to investigate voltages and currents of a combination of resistors. The data confirms the law, as the slopes were found to be 1.

References

Fluke. (2023, Dec). *What is ohm's law?* Retrieved from `https://www.fluke.com/en-us/learn/blog/electrical/what-is-ohms-law`