Laboratory Notebook

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PHYS 122.E13

Experiment 8: Basic Rules in Series & Parallel Circuits

Equipment: Two 1.5-V batteries, one switch, one ammeter, some wires, one voltmeter, one 5-Ω resistor, one 10-Ω resistor.

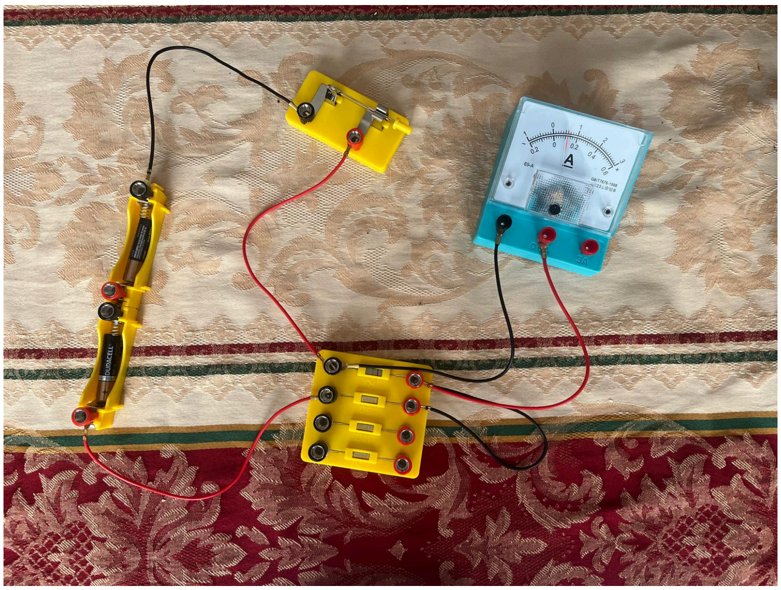


Figure 8

Data & Analytics: The relationship between V from V1 and V2 is that V1+V2 = V. The relationship between I1 and I2 is that I1 + I2 = I. The relationship from Experiment C showcases that V1 = V2 = V. In a series circuit, the total voltage drop across the series elements equals the sum of the voltage drops across each element, as V = IR. In a parallel circuit, the total current flowing from the battery equals the sum of the currents through each parallel branch. Each branch has its own current determined by its resistance and the applied voltage. In a parallel circuit, the voltage drop across each resistor is the same and equals the total voltage supplied by the battery.

Conclusion: In series circuits, the current is the same through all components. The total voltage drop is the sum of the individual voltage drops across each component. Because the same current flows through each part of a series circuit, I = I1 = I2 = I3, and V = V1 + V2 + V3. The relationship of current in a series circuit is equal to the potential difference of the source divided by the equal resistance. In parallel Circuits, the voltage drop across each parallel branch is the same. The total current is the sum of the currents through each branch. I = I1 + I2 + I3, and V = V1 = V2 = V3. The reciprocal of the equivalent resistance is equal to the sum of the reciprocals of the individual resistances.

Experiment 9: Basic Rules in Series & Parallel Circuits

Equipment: Three 1.5-V batteries, one ammeter, one voltmeter, one 5-Ω resistors, one 10-Ω resistor, one 20-Ω resistor, one potentiometer, one switch, some wires

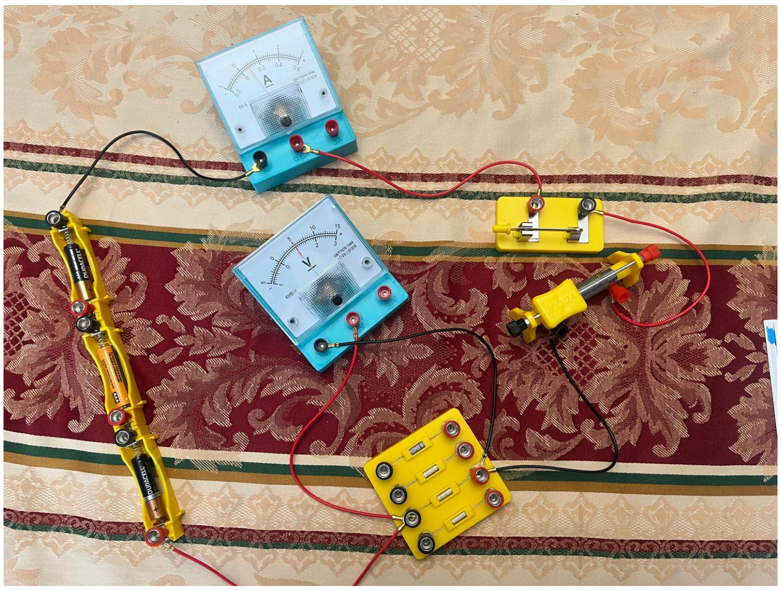
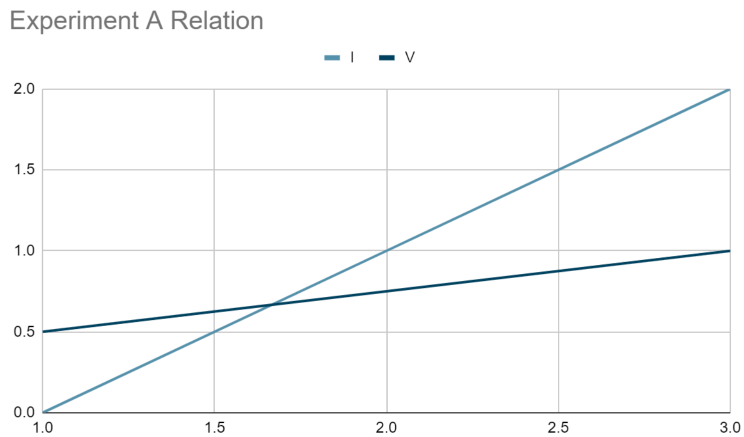


Figure 9

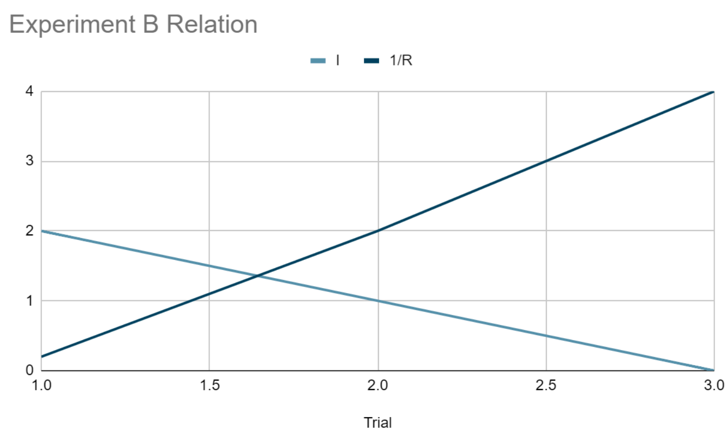
Data & Analytics: In Experiment A, the control variable was the resistance of the resistor, and in Experiment B, the voltage was the control variable.

Trial	I	V
1	0	0.5
2	1	0.75
3	2	1

Trial	I	R	1/R
1	2	5	0.2
2	1	10	2
3	0	20	4



By keeping a consistent resistance with Experiment A, I was able to determine that increasing the I factor linearly affected the voltage. This relationship exists because increasing the electrical current would directly increase the voltage.



By keeping a consistent voltage with Experiment B, I was able to determine a relationship between I and 1/R, where decreasing I led to an increased 1/R, showcasing an inverse relationship between 1/R and I.

Conclusion: In this lab, we investigated the relationships between voltage, current, and resistance, confirming the fundamental principles of Ohm's Law. In Experiment A, we varied the voltage across a constant resistance and observed that the current increased linearly with the voltage, indicating a direct proportionality between current and voltage. This was visually confirmed by plotting current versus voltage, which produced a straight line. In Experiment B, we examined the effect of varying resistance on the current for a fixed voltage. We found that the current decreased as the resistance increased, demonstrating an inverse relationship between current and resistance. Plotting current against the reciprocal of resistance resulted in a straight line, supporting the direct proportionality between current and the reciprocal of resistance. Combining these results, we derived Ohm's Law. This formula succinctly describes how current is directly proportional to voltage and inversely proportional to resistance. Overall, the lab provided empirical evidence for Ohm's Law, highlighting the importance of controlled variables and reinforcing our understanding of electrical circuit principles.

Experiment 10: Measurement of an Unknown Resistance by Current-Voltage Method

Equipment: Three 1.5-V batteries, one ammeter, one voltmeter, one unknown resistor, one potentiometer, one switch, some wires

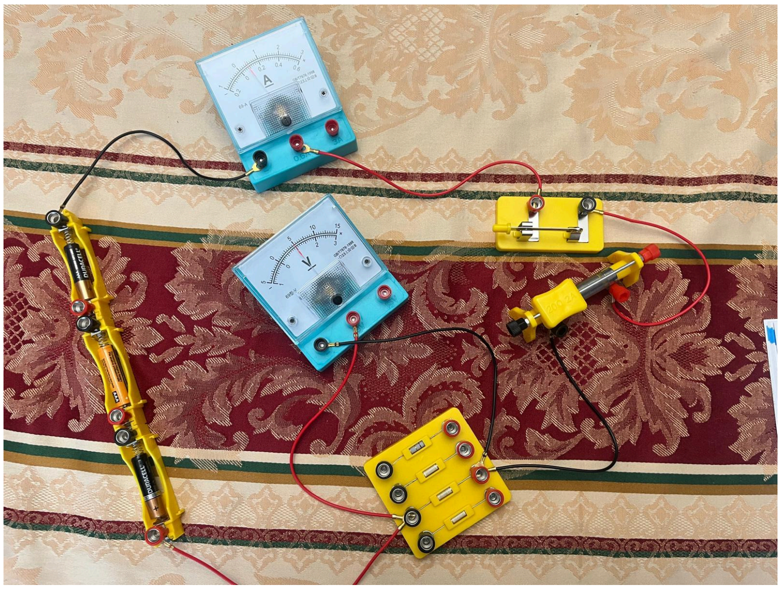


Figure 10

Data & Analytics: The factors that could have affected the result of the experiment include the temperature, the precision of measurement, and calibration of the ammeter and voltmeter. The need for lab data stems from averaging out random errors and the ability to detect anomalies. The potentiometer was included to adjust the current through the circuit, providing multiple data points. It also allows for more precise measurements.

Trial	Current	Voltage	Resistance
1	0.1	0.5	5
2	0.1	0.55	5.5
3	0.9	0.46	5.1

Conclusion: To measure an unknown resistance using the current-voltage method, we apply Ohm's law, which states that R=V/I. In this method, we set up a circuit with a known current path including an ammeter, voltmeter, potentiometer, and the unknown resistor. By varying the potentiometer, we adjust the current and measure both the current (I) through and the voltage (V) across the unknown resistor. For each measurement, we calculate the resistance using the formula R=V/I. For instance, if we measure a current of 0.20 A and a voltage of 1.00 V, the resistance is $R=1.00\ V/\ 0.20\ A=5\ \Omega$. Repeating this process for different current values still allows for an average value around 5. Multiple trials provide a reliable average resistance value, minimizing errors. Averaging the calculated resistances ensures accuracy, confirming that our unknown resistor is approximately 5 Ω. This method illustrates the practical application of Ohm's law in determining resistance by directly measuring voltage and current.

Experiment 11: Magnetic Field

Equipment: One bar magnet, one horseshoe magnet, one compass, one iron fillings box

Figure 11

Data & Analytics: When placing the compass on a horizontal surface, the needle takes a moment to stabilize. Moving the north pole of a bar magnet towards the north pole of a horseshoe magnet results in repulsion, whereas moving it towards the south pole of the horseshoe magnet causes attraction. When an iron object is rubbed with the magnet and then brought near iron filaments, the filaments are attracted to the magnet. Placing the horseshoe magnet near the compass causes the red terminal (the north pole) to be attracted to the north side of the horseshoe magnet, and the white terminal to the south side. Like poles repel and opposite poles attract. The red terminal of the compass needle is the north pole, aligning with Earth's magnetic north. The needle turns when its position changes to align with the magnetic field lines, indicating direction at that point.

Conclusion: This experiment demonstrates fundamental properties of magnets and magnetic fields. When placed on a horizontal surface, a compass needle requires time to stabilize due to the alignment process with Earth's magnetic field. The interactions between the bar magnet and the horseshoe magnet reinforce the principle that like poles repel and opposite poles attract. This was evident when the north pole of the bar magnet repelled the north pole of the horseshoe magnet and attracted its south pole. Rubbing an iron object with a magnet and observing its effect on iron filaments illustrated that magnetic properties can be induced in certain materials. The response of the compass to the horseshoe magnet further highlighted the directional nature of magnetic fields, with the compass needle aligning itself along these invisible lines of force. The red terminal of the compass needle, representing the north pole, was attracted to the south pole of the horseshoe magnet, and vice versa. Overall, the experiment confirms that magnetic fields exert directional forces, causing aligned materials such as a compass needle to orient themselves along these fields. This behavior is due to the intrinsic properties of magnets, which have distinct north and south poles that interact predictably with each other and with induced magnetic materials. These observations are consistent with the fundamental principles of magnetism and provide a clear understanding of magnetic interactions and field alignment.

Experiment 12: Magnetic Effect of Electric Current

Equipment: Three 1.5-V batteries, one copper rod, one compass, one double rail module, one switch, some wires

Figure 12

Data & Analytics: When the switch is closed and current flows through the copper rod, the compass needle deflects, indicating that the electric current produces a magnetic field around the rod. Upon opening the switch, the current stops, causing the magnetic field to disappear and the compass needle to return to its original position, aligned with the Earth's magnetic field. Reversing the current direction results in the compass needle deflecting in the opposite direction, demonstrating that the magnetic field's direction depends on the current's direction.

Conclusion: The lab explores the magnetic effect of electric current, a fundamental concept in electromagnetism. By setting up a circuit with three 1.5-V batteries, a copper rod, a compass, and other components, the experiment demonstrates how electric current generates a magnetic field. When current flows through the copper rod, the nearby compass needle deflects, showing the presence of a magnetic field. This field disappears when the current stops, as observed when the switch is opened and the compass needle returns to its original position. Reversing the direction of the current causes the compass needle to deflect in the opposite direction, highlighting the dependency of the magnetic field direction on the current flow. The experiment underscores the relationship between electricity and magnetism, illustrating key principles that are essential in the functioning of devices like electromagnets and electric motors. Observing these effects helps in understanding the fundamental laws of electromagnetism and their applications in various technologies. It also emphasizes the importance of careful handling of electrical components to prevent overheating and ensure safety during experiments.

Experiment 13: Electromagnet

Equipment: Three 1.5-V batteries, one solenoid, one ammeter, one potentiometer, one switch, some wires, some paper clips

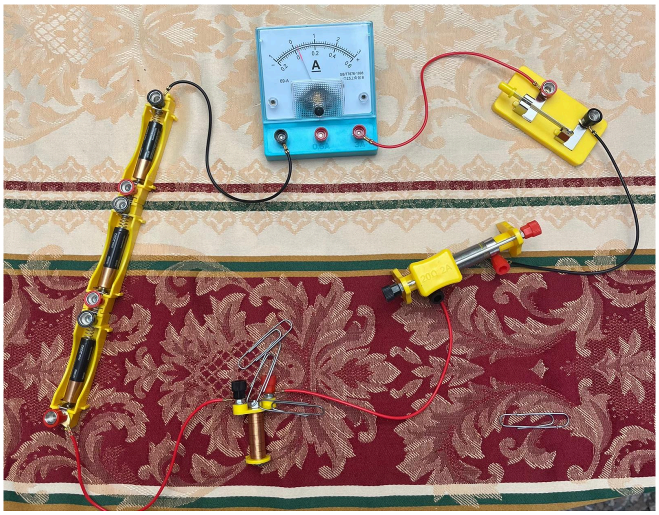


Figure 13

Data & Analytics:
From the experiment, it is evident that the presence of an iron core inside the solenoid significantly enhances its magnetic field strength, as indicated by the increased number of paper clips attracted. The strength of the current flowing through the solenoid also directly impacts its magnetic field; higher currents result in stronger magnetic fields, attracting more paper clips, while lower currents produce weaker fields. Other factors that influence the magnetic field strength include the number of turns in the coil, with more turns creating a stronger field, and the material of the core, where materials with higher magnetic permeability, like iron, amplify the field. Additionally, the cross-sectional area of the coil affects the field strength, with larger areas accommodating more magnetic flux. The length of the solenoid also plays a role, as a shorter solenoid with the same number of turns will have a stronger magnetic field due to the denser packing of turns. Thus, the key factors impacting the strength of an electromagnet's magnetic field are current strength, number of coil turns, core material, coil cross-sectional area, and solenoid length. Understanding these factors allows for the optimization of electromagnets for various applications by adjusting these parameters to achieve the desired magnetic field strength.

Conclusion: In this lab, we investigated the factors that affect the strength of an electromagnet's magnetic field. By constructing a solenoid and measuring its ability to attract paper clips, we observed that an iron core significantly enhances the magnetic field strength. The strength of the current through the solenoid also directly impacts the magnetic field, with higher currents producing stronger fields. Additionally, we found that the number of turns in the coil, the material of the core, the coil's cross-sectional area, and the solenoid's length are crucial factors. More turns and materials with high magnetic permeability, like iron, increase the field strength. A larger cross-sectional area accommodates more magnetic flux, and a shorter solenoid with dense turns results in a stronger field. Understanding these factors allows for optimizing electromagnets for various applications. This experiment reinforced theoretical concepts and provided practical insights into manipulating and measuring magnetic fields, deepening our understanding of electromagnetism.

Experiment 14: Forces on Current in Magnetic Fields

Equipment: Three 1.5-V batteries, one double-rail module, one switch, one ammeter, one copper rod, one horseshoe magnet, one potentiometer, some wires

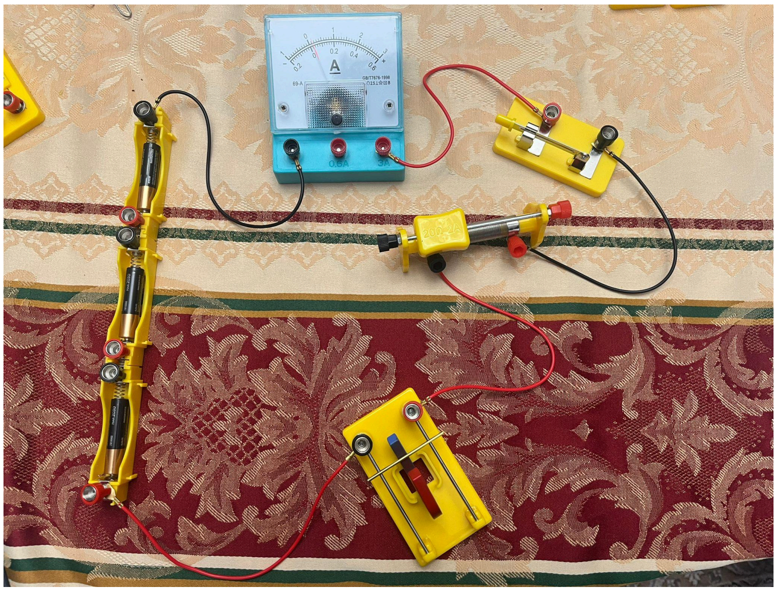


Figure 14

Data & Analytics: Before the current reached a certain strength, the copper rod remained stationary, but after the current reached a threshold strength, the rod experienced a force and moved. This occurs because a stronger current generates a larger magnetic field around the conductor, increasing the interaction with the magnetic field of the horseshoe magnet, resulting in a noticeable force on the rod. When the direction of the current was reversed, the direction of the force on the copper rod also reversed, consistent with the right-hand rule. Changing the direction of the magnetic field similarly reversed the direction of the force on the copper rod. This is because the force experienced by the conductor depends on both the direction of the current and the magnetic field, as described by the right-hand rule. The right-hand rule states that if you point your thumb in the direction of the current and your fingers in the direction of the magnetic field, the force exerted on the conductor will be in the direction your palm pushes. Therefore, reversing either the current or the magnetic field reverses the direction of the force. This experiment illustrates how electromagnetic forces act on current-carrying conductors within magnetic fields and emphasizes the practical application of the right-hand rule.

Conclusion: This experiment demonstrates the interaction between a current-carrying conductor and a magnetic field, a fundamental concept in electromagnetism. By placing a copper rod between the poles of a horseshoe magnet and passing a current through it, we observed that the rod experiences a force perpendicular to both the current and the magnetic field. This force causes the rod to move, and its direction can be predicted using the right-hand rule. Reversing the direction of the current or the magnetic field reverses the direction of the force, highlighting the vector nature of these quantities. The force increases with the current's strength, indicating a proportional relationship. This experiment illustrates how electromagnetic forces are used in various applications, such as electric motors and generators. Understanding this principle is crucial for designing and operating devices that rely on electromagnetic interactions. The practical application of the right-hand rule provides a reliable method for predicting the behavior of current-carrying conductors in magnetic fields.