Ohm's law

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Ohm's Law, formulated by German physicist Georg Simon Ohm, describes the relationship between current, resistance, and voltage in an electrical circuit. This fundamental principle, established by Ohm in 1827, indicates that the voltage drop across a conductor is the product of the current flowing through it and the conductor's resistance. Through his experiments, Ohm demonstrated how the interplay between these variables—current (I), voltage (V), and resistance (R)—defines the behaviour of electric circuits.

I. Ohm's law

Ohm's Law is a fundamental principle that explains the relationship between voltage, current, and resistance in an electrical circuit. It basically tells us how much electricity (current) flows through a wire (conductor) when a certain voltage is applied, assuming everything else stays the same (like temperature). Imagine voltage as water pressure and current as the amount of water flowing through a pipe. The wider the pipe (lower resistance), the more water (current) can flow for a given amount of pressure (voltage). According to Ohm's Law, current is directly proportional to voltage. This means if you double the voltage, you'll also double the current, all things being equal. Ohm's Law is written as $V \propto I$, where V represents voltage and I represents current. The proportionality symbol ($\propto$) means "directly proportional to." This law is a cornerstone for understanding and working with electrical circuits, allowing us to predict how much current will flow based on the applied voltage and vice versa.

II. Ohm's law explanation

Ohm's Law is one of the fundamental laws of electrostatics which state that, the voltage across any conductor is directly proportional to the current flowing in that conductor. We can define this condition as:

$$\mathbf{V \propto I}$$

Removing the proportionality sign:

$$\mathbf{V = RI}$$

where R is the proportionality constant and is called the Resistance of the material. The resistance of the material is calculated as,

$$\mathbf{R = V/I}$$

Resistance is measured in Ohms. It is denoted by the symbol Ω.

III. Ohm's law formula

When all physical parameters and temperatures remain constant, Ohm's law states that the voltage across a conductor is directly proportional to the current flowing through it.

Ohm's law can be expressed as:

$$\mathbf{V \propto I \text{ or } V = I \times R}$$

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Where:

- R is the Constant of proportionality known as Resistance,
- V is the Voltage applied, and
- I is the current flowing through the electrical circuit.

The above formula can be rearranged to calculate current and resistance also, as follows:

According to Ohm's law, the current flowing through the conductor is,

I = V / R

Similarly, resistance can be defined as,

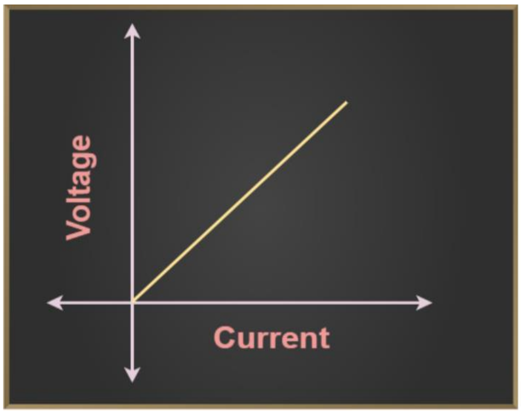
R = V / I

IV. Ohm's law graph

Ohm's Law is a fantastic tool for understanding electricity, but it has its limits. For it to be truly accurate, things need to stay stable inside the circuit, especially temperature.

Imagine a highway for electrons – that's what a circuit is like. Ohm's Law helps us predict how much traffic (current) will flow smoothly based on the pressure (voltage) applied. However, if the highway gets too hot (temperature increases), things can slow down. This is because some materials, like the filament in a light bulb, conduct electricity differently at higher temperatures. As the bulb heats up with more current flowing through it, the flow of electricity becomes less predictable, causing a deviation from Ohm's Law. In other words, Ohm's Law works best when the temperature in the circuit remains constant.

The graph for an ohmic circuit is shown in the image below:



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V. Ohm's law unit

There are three physical quantities that are associated with the Ohms law that include:

- **Current**
- **Voltage**
- **Resistance**

The table added below shows the various symbol and their unit used:

Physical Quantity	Unit of Measurement	Unit Abbreviation
Current(C)	Ampere	A
Voltage(V)	Volt	V
Resistance(R)	Ohm	Ω

VI. Ohm's law equations

Ohm's law provides three equations which are:

- **V = I × R**
- **I = V / R**
- **R = V / I**

Where:

- V is the voltage,
- I is the current, and
- R is the resistance.

VII. Relationship between Voltage, Current, and Resistance: Ohm's law

The relation between voltage, current, and resistance can easily be studied using the formula,

V = IR

Where:

- V is the voltage,
- I is the resistance, and
- R is the resistance.

We can study this formula with the help of the table discussed below,

Voltage	Current	Resistance

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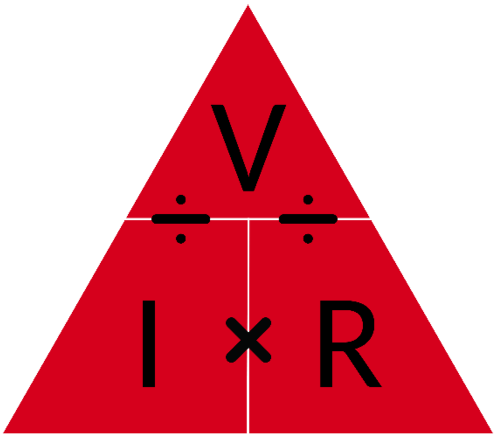
2 V	1/2 A	4 Ω
4 V	1 A	4 Ω
8 V	2 A	4 Ω

VIII. Ohm's law triangle

Ever struggle to remember the connection between voltage, current, and resistance in a circuit? The Ohm's Law triangle is your secret weapon! This handy visual tool helps you understand and memorize the relationship between these three key electrical players: current (I), voltage (V), and resistance (R).

Think of the triangle as a map. The position of each element within the triangle tells you the formula to solve for the missing piece. It's a quick and easy way to refresh your memory, whether you're an engineer or just trying to understand the basics of electricity.



IX. Vector form of Ohm's law

The relation between current and voltage is established by, Ohm's law, and its vector form is:

$$\mathbf{j} = \sigma \mathbf{E}$$

Where,

- j is Current Density vector,
- E is Electric Field vector, and
- σ is conductivity of material.

Resistivity

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The hindrance faced by the electrons while moving in any material is called the resistivity of the material. Let a resistor of a length of 'l' and the cross-sectional area of 'A' has a resistance be R. **Then we know:**

- **Resistance is directly proportional to the length of the resistor, i.e. R ∝ l, . . .(1)**
- **Resistance is inversely proportional to the cross-section area of the resistor, i.e. R ∝ 1/A . . .(2)**
- **combining eq. (1) and eq.(2)**

$$R = \rho l / A$$

Where **ρ** is the proportionality constant called coefficient of resistance or resistivity.

Now if L = 1m and A = 1 m2, in the above formula we get,

$$R = \rho$$

This means for a resistor of length 1 m and cross-section area 1 m2 the resistance is called the resistivity of the material.

X. Experimental verification of Ohm's law

Ohm's Law tells us there's a predictable relationship between voltage, current, and resistance in an electrical circuit. But how do we know it's true? Here's a breakdown of an experiment to verify this law:

Tools of the trade:

- **Resistor:** this acts like a roadblock for electricity, creating resistance.
- **Ammeter:** this instrument measures the current flowing through the circuit, like a traffic counter for electrons.
- **Voltmeter:** this tool measures the voltage (electrical pressure) pushing the current through the circuit.
- **Battery:** this is the power source, like a pump that keeps the electrons flowing.
- **Plug Key:** this acts like a light switch, controlling the flow of electricity in the circuit.
- **Rheostat:** this variable resistor allows us to adjust the resistance in the circuit, like a dimmer switch for electricity.

Building the Circuit:

The next step is building the circuit based on the provided diagram. This diagram will show how all the components are connected to create a closed loop for the electricity to flow.

By varying the resistance with the rheostat and measuring the voltage and current at each setting, we can see if the relationship between these elements holds true as predicted by Ohm's Law.

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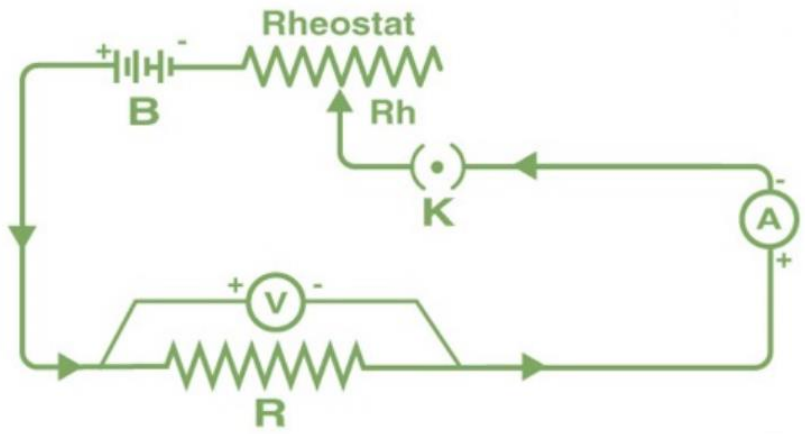

Ohm's Law isn't just a theory; we can put it to the test! Here's how to conduct an experiment to verify this law:

1. **Setting the stage:**
   - Start with the switch (key K) off and adjust the rheostat (a variable resistor) to its lowest setting. This minimizes the readings on the ammeter (A) which measures current and the voltmeter (V) which measures voltage.
2. **Turning up the current:**
   - With the switch still off, slowly adjust the rheostat to increase the resistance in the circuit. Turn on the switch and record the current reading on the ammeter and the voltage reading on the voltmeter for each new resistance setting.
3. **The magic ratio:**
   - Now comes the key part! For each set of voltage (V) and current (I) readings you recorded, calculate the ratio V/I.
4. **Seeing is believing:**
   - After calculating this ratio (V/I) for multiple current and voltage readings, you'll likely notice something interesting: the ratio stays relatively constant! This is a strong indication that Ohm's Law holds true.
5. **The graphical proof:**
   - Take all your data and plot a graph with current (I) on the x-axis and voltage (V) on the y-axis. If Ohm's Law is correct, the graph should be a straight line. This straight line confirms the direct proportionality between current and voltage as described by Ohm's Law. The slope of this line will also correspond to the resistance of the wire used in the experiment.

By following these steps and observing the near-constant ratio and the straight line graph, you've successfully verified Ohm's Law through experimentation!

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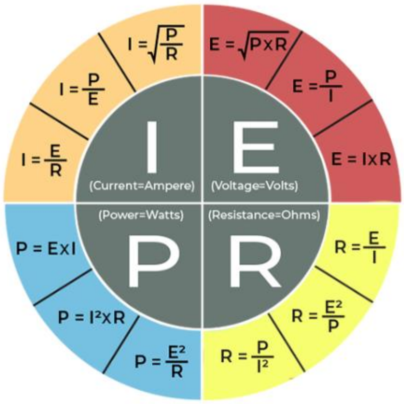
XI. Ohm's law pie chart

Juggling multiple equations to find voltage, current, resistance, and power can get confusing. The Ohm's Law pie chart comes to the rescue! This handy tool condenses all those equations into a simple visual representation, as shown below.

Imagine the pie chart is a roadmap for solving these electrical problems. Each section of the pie represents one variable (voltage, current, resistance) and its relationship to the other two. This visual approach makes it easier to understand and remember the key formulas associated with Ohm's Law.



XII. Ohm's law matrix table

Ohm's law formulas (Given parameters)	To Calculate: Voltage (V)	Current (I)	Resistance (R)	Power (P)
Power & Resistance	$V = \sqrt{P.R}$	$I = \sqrt{P/R}$	___	___
Voltage & Power	___	$I = \frac{P}{V}$	$R = \frac{V^2}{P}$	___
Voltage & Resistance	___	$I = \frac{V}{R}$		$P = \frac{V^2}{R}$
Voltage & Current	___	___	$R = \frac{V}{I}$	$P = VI$
Current & Power	$V = \frac{P}{I}$	___	$R = \frac{P}{I^2}$	___
Current & Resistance	$V = I*R$	___	___	$P = I^2R$

Just like the Ohm's Law pie chart, we can organize the individual Ohm's Law equations into a convenient matrix table, as shown below. This table is a handy reference when you need to calculate an unknown value in a circuit. Each cell in the table shows the formula for calculating a specific unknown variable (Voltage, Current, or Resistance) based on the two known values. For example, if you know the current (I) and resistance (R) in a circuit, you can use the formula in the "Voltage (V)" row to calculate the voltage (V).

This table is a great way to quickly find the right equation whenever you're working with Ohm's Law!

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XIII. Applications of Ohm's law

Ohm's Law is a superstar when it comes to understanding electricity in circuits. It lets you find the missing piece (voltage, current, or resistance) as long as you know the other two!

Here are some of the ways Ohm's Law comes in clutch:

- Power up your calculations: it makes figuring out power in a circuit a breeze.
- Maintaining voltage balance: Ohm's Law helps ensure the right voltage reaches different parts of your circuit.
- Circuit sleuthing: need to find voltage, resistance, or current in a circuit? Ohm's Law is your go-to tool.
- Current redirection magic: Ohm's Law even plays a role in redirecting current in certain electrical components.

Ohm's Law in action: unveiling the current-voltage relationship

Imagine a graph with voltage on the y-axis and current on the x-axis. Thanks to Ohm's Law, for a constant resistance, this graph will be a straight line. The ratio of voltage to current (V/I) stays consistent, which explains the straight line.

Finding the mystery resistance:

This constant ratio (V/I) is the key to unlocking unknown resistance values. For wires with a uniform cross-section, the resistance depends on two things: length and the area of the wire. Temperature also plays a role – resistance can change as temperature increases.

The text mentions a formula for resistance at a specific temperature, but it doesn't go into detail. If you're interested in learning more about that specific formula, I can provide some resources for further exploration.

$$R = \rho L / A$$

Where:

- ρ is the specific resistance or resistivity and is the wire material's characteristic.

The wire material's specific resistance or resistivity is,

$$\rho = R A / L$$

XIV. Calculating electrical power using Ohm's law

Electricity is all about the flow of tiny charged particles. The rate at which this electrical energy gets used up is called electric power. We measure this power in watts (W).

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Ohm's Law is a handy tool to help us calculate the power in an electrical circuit. Here's the secret sauce:

P = VI

Where:

- P is the power of the circuit,
- V is the voltage across the circuit, and
- I is the current passing through the circuit.

We know that, using Ohm's Law

V = IR

Using the power formula we get,

this formula is useful when you know the voltage and resistance but not the current:

P = V2/R

this formula is handy when you know the current and resistance but not the voltage:

P = I2R

XV. Limitations of Ohm's law

Ohm's Law is a fantastic tool for understanding circuits, but it has its limits. Here are some situations where it won't give you the whole picture:

- **One-way streets (unilateral networks):** Ohm's Law doesn't apply to circuits that only allow current to flow in one direction. These circuits, often used in electronics, contain components like diodes and transistors.
- **Non-Linear components:** imagine a light bulb – the more current you push through it, the hotter it gets and the more its resistance changes. In these non-linear components, the relationship between current and voltage isn't a straight line, so Ohm's Law won't give you an accurate picture. Thyristors are a type of non-linear component.

XVI. Analogies of Ohm's Law

There are various analogies given in the past to explain Ohm's law, some of the most common analogies are:

- Water pipe analogy
- Temperature analogy

Ohm's Law might seem abstract, but fear not! Let's bring it to life with two relatable analogies:

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The water pipe analogy: flow like electricity

Imagine electricity as water flowing through a pipe. The current (flow of electrons) is like the amount of water moving through the pipe. Just like water pressure pushes water through the pipe, voltage is the "electrical pressure" that pushes current through a circuit. The higher the voltage (pressure), the more current (water) flows, following Ohm's Law. Think of a garden hose – the harder you squeeze (higher pressure), the more water (current) shoots out.

The temperature analogy: heat on the move

Here's another analogy: imagine heat flowing through a material like a metal rod. The temperature difference between the two ends of the rod acts like voltage. The greater the temperature difference (higher "thermal pressure"), the more heat flows through the rod, similar to how current increases with voltage. This heat flow acts like the current in an electrical circuit. So, just like a bigger temperature difference moves more heat, a higher voltage pushes more current through a conductor (material that allows electricity to flow).

These analogies help us visualize the relationship between voltage, current, and resistance in an electrical circuit, making Ohm's Law more intuitive.

XVII. Tasks on the use of Ohm's law

Use our online laboratory to solve tasks: https://lab.oleeproject.eu/#

Task #1: Find the resistance of an electrical circuit with a voltage supply of 15 V and a current of 3 mA.

Task #2: If the resistance of an electric iron is 10 Ω and a current of 6 A flows through the resistance. Find the voltage between two points.

Task #3: Find the current passing through the conductor drawing 20 volts when the power drawn by it is 60 watts.

Task #4: A battery of 6 V is connected to the bulb of resistance 4 Ω. Find the current passing through the bulb and the circuit's power.

XVIII. Tasks solving procedure

Task #1: Find the resistance of an electrical circuit with a voltage supply of 15 V and a current of 3 mA.

Solution

Given:

- V = 15 V
- I = 3 mA = 0.003 A

The resistance of an electrical circuit is given as:

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R = V / I

1. R = 15 V / 0.003 A
2. R = 5000 Ω
3. R = 5 kΩ

The resistance of an electrical circuit is ***5 kΩ.***

Task #2: If the resistance of an electric iron is 10 Ω and a current of 6 A flows through the resistance. Find the voltage between two points.

Solution

Given:

- I = 6 A, R = 10 Ω

The formula to calculate the voltage is given as:

V = I × R

1. V = 6 A × 10 Ω
2. V = 60 V

The voltage between two points is ***60 V.***

Task #3: Find the current passing through the conductor drawing 20 volts when the power drawn by it is 60 watts.

Solution:

According to Ohm's **P = VI**

Given: P = 60 watt, V = 20 volt

1. I = P/V
2. I = 60/20
3. I = 3 A

The current flowing through the conductor is ***3 A***

Task #4: A battery of 6 V is connected to the bulb of resistance 4 Ω. Find the current passing through the bulb and the circuit's power.

Solution:

Given:

- V = 6 V
- R = 4 Ω

We know that:

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V = IR (Ohm's Law)

1. 6 = 4R
2. I = 6 ÷ 4 = 1.5 A
3. I = 1.5 A

a) thus, the current flowing through the bulb is 1.5 A
b) for the Power of the circuit: **P = VI**

1. P = (6)(1.5)
2. P = 9 watt

*Thus, the power of the circuit is **9 watts.***

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