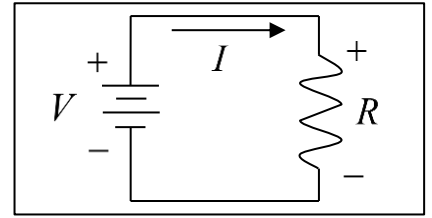


Elementary Engineering Mathematics

Application of Lines in Electric Circuits

DC Circuit with a Single Resistor

A direct current (DC) circuit with a single resistor is shown in the diagram. The symbol V represents the applied voltage, the symbol R represents the resistance of the resistor, and the symbol I represents the current flowing through the circuit.



Symbol	Description	Units
V	Applied voltage (e.g. battery voltage)	volts (V)
R	Resistance of resistor	ohms (Ω)
I	Current passing through the circuit	amps (A)

There are *two important laws* that enable us to relate these three variables, **Ohm's Law** and **Kirchhoff's Voltage Law**.

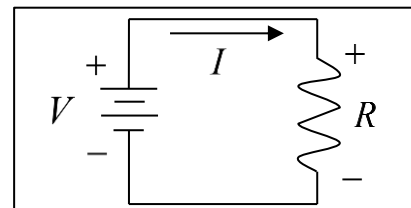
	Equation	Description
Ohm's Law	$V_R = R I$	The voltage drop across the resistor is the product of its resistance and the current passing through it.
Kirchhoff's Voltage Law	$\sum(\text{voltage rises}) = \sum(\text{voltage drops})$	The sum of voltage rises must equal the sum of the voltage drops around any loop in a circuit.

Applying Kirchhoff's voltage law and Ohm's law to the circuit gives $V = V_R = R I$. This is the equation of a line relating the current to the applied voltage. The slope (m) of the line is the resistance R , and the intercept (b) is zero.

Example #1

Given: For the circuit shown, the following data were measured.

V (volts)	I (amps)
5	0.05
10	0.1



Find: The resistance R .

Solution:

The **current** is related to the **applied voltage** by the equation $V = RI$, so we can find the resistance by finding the slope of the line.

$$R = m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{V_2 - V_1}{I_2 - I_1} = \frac{10 - 5}{0.1 - 0.05} = 100 \text{ (ohms, } \Omega)$$

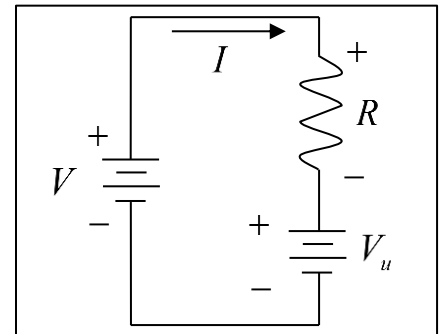
So now we have: $V = 100 I$

Note: Because the **intercept** is **zero**, we could have used the point $(x_1, y_1) = (0, 0)$ with either of the data values given.

Example #2

Given: In the circuit shown, V is a **known** constant voltage source and V_u is an **unknown** constant voltage source. For the circuit shown, the following data were measured.

V (volts)	I (amps)
15	0.03333
30	0.1333



Find: The resistance R and the unknown voltage source V_u .

Solution:

Applying Kirchoff's voltage law to this circuit gives $V = V_R + V_u = RI + V_u$. So, the resistance R is the **slope** (as before), and the unknown voltage V_u is the **intercept**.

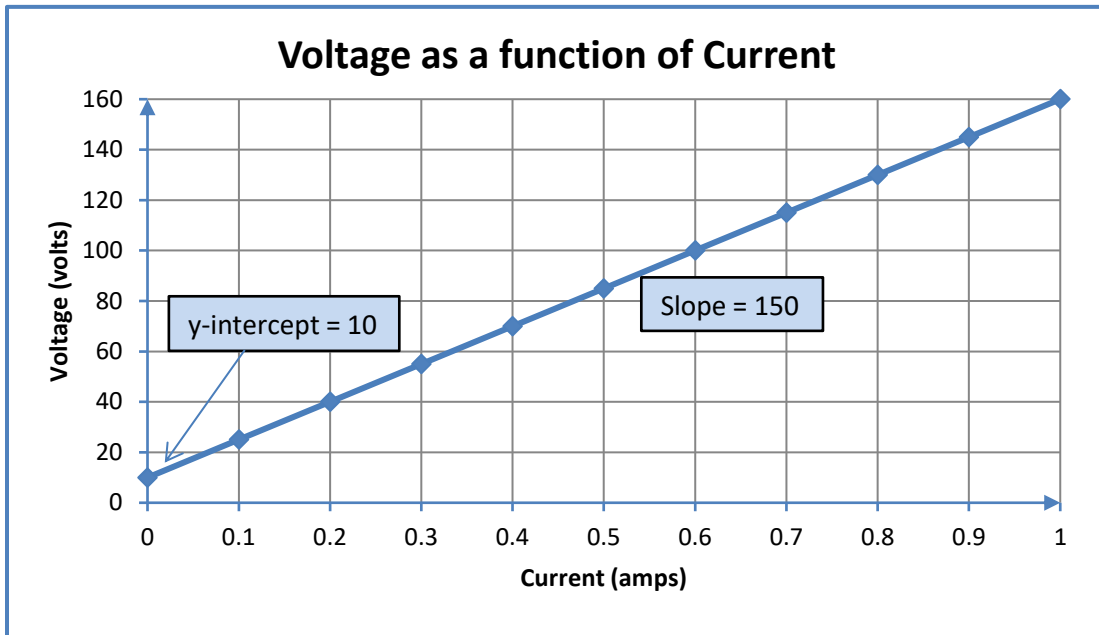
$$R = m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{V_2 - V_1}{I_2 - I_1} = \frac{30 - 15}{0.1333 - 0.03333} = 150.05 \approx 150 \text{ (}\Omega)$$

So now we have: $V = 150 I + V_u$

To find the intercept, we use this result with **either** of the two data points.

$$V_u = V - 150 I = \begin{cases} 15 - (150 \times 0.03333) = 10.0005 \approx 10 \text{ (volts)} \\ \text{or} \\ 30 - (150 \times 0.1333) = 10.005 \approx 10 \text{ (volts)} \end{cases}$$

We now have the completed equation: $V = 150 I + 10$



Example #3

In the above examples, the *current* I is the *independent* variable and the *voltage* V is the *dependent* variable. We can easily reverse these roles by solving the completed equation for the current I as a function of the voltage V .

$$V = 150I + 10 \Rightarrow 150I = V - 10 \Rightarrow I = \left(\frac{1}{150}\right)V - \left(\frac{10}{150}\right)$$

