

## Ohm's Law

By measuring the amount of current that a given voltage produces, Ohm was able to calculate the circuit's resistance. **Electrical resistance** is the ratio of the voltage to the current. The unit of measurement for electrical resistance is the **ohm** ( $\Omega$ ). The mathematical relationship comparing voltage ( $V$ ), current ( $I$ ), and resistance ( $R$ ) is called **Ohm's law** and is written as:

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

Ohm's law is more commonly written in the form:

$$V = IR$$

You can use Ohm's law to calculate resistance.

### Read the question:

What is the resistance of a flashlight bulb if there is a current of 0.75 A through the bulb when connected to a 3.0 V battery?

### Use the formula:

$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{3.0 \text{ V}}{0.75 \text{ A}} \\ &= 4.0 \Omega \end{aligned}$$

### State your answer:

The resistance of the flashlight bulb is 4.0  $\Omega$ .

## Word Connect

The symbol for the unit of the ohm is the Greek letter omega ( $\Omega$ ) instead of the first letter of ohm (O). This is because the (O) might be confused as the number zero. The symbol "I" for current stands for "intensity."

## Practice Problems

Try the following Ohm's law problems. Show each step of your solution.

1. The current through a load in a circuit is 1.5 A. If the potential difference across the load is 12 V, what is the resistance of the load?
2. The resistance of a car headlight is 15  $\Omega$ . If there is a current of 0.80 A through the headlight, what is the voltage across the headlight?
3. A 60 V potential difference is measured across a load that has a resistance of 15  $\Omega$ . What is the current through this load?

### Answers

1. 8.0  $\Omega$
2. 12 V
3. 4.0 A

## Converting prefixes

Prefixes are used to indicate the magnitude of a value.

*milli* (m) represents one-thousandth (example: 25 mA =  $\frac{25}{1000}$  A = 0.025 A)

*kilo* (k) represents one thousand (example: 5.0 k $\Omega$  = 5000  $\Omega$ )

*mega* (M) represents one million (example: 12 MV = 12 000 000 V)

When solving a problem where some of the units contain prefixes, first convert the prefixes before you do your calculation.

### Read the question:

What is the voltage across a  $12\text{ k}\Omega$  load that allows a current of  $6.0\text{ mA}$ ?

### Use the formula:

$$\begin{aligned}V &= IR \\ &= (6.0\text{ mA})(12\text{ k}\Omega) \\ &= (0.0060\text{ A})(12\,000\ \Omega) \\ &= 72\text{ V}\end{aligned}$$

### State your answer:

The voltage across a  $12\text{ k}\Omega$  load is  $72\text{ V}$ .

### Answers

1.  $6.0\text{ V}$
2.  $7.5\text{ mA}$
3.  $100\,000\ \Omega$ ;  $100\text{ k}\Omega$

### Practice Problems

Try the following Ohm's law problems. Show each step of your solution. Remember to convert prefixes before calculating.

1. A  $15\text{ mA}$  current flows through a  $400\ \Omega$  lamp. What is the voltage across the lamp?
2. A  $12\text{ k}\Omega$  load is connected to a  $90\text{ V}$  power supply. What is the current through the load in milliamperes (mA)?
3. A device draws a current of  $1.2\text{ mA}$  when connected to  $120\text{ V}$ . What is the resistance of this device? Give your answer in both ohms and kilo-ohms.

### Did You Know?

The current flowing in an MP3 player is very small, perhaps one-thousandth of an ampere. The current produced by a car's battery to start the car is almost  $100\text{ A}$ .

### Determining the Resistance

There are several methods you can use to determine the resistance.

*Method 1:* To experimentally measure the resistance of a device or load, the load must be connected to a source of potential difference, such as a battery. You can use a voltmeter to measure the voltage across the load and an ammeter to measure the current through the load. Then you can use Ohm's law to calculate the resistance.

To obtain more accurate results, you can place several different voltages across the load. You then measure the current through the load for each voltage. Using Ohm's law, you can calculate the load's resistance for each set of data. These resistances can then be compared.

*Method 2:* In your classroom, you may have used a digital multimeter to take your voltage and current measurements. Most multimeters also have a setting for measuring resistance. An **ohmmeter** is a device that measures resistance. When a multimeter is used as an ohmmeter, the meter uses its internal battery to provide a voltage across the load. The meter measures the current leaving the battery and calculates the resistance. This calculated resistance is then shown on the display screen.