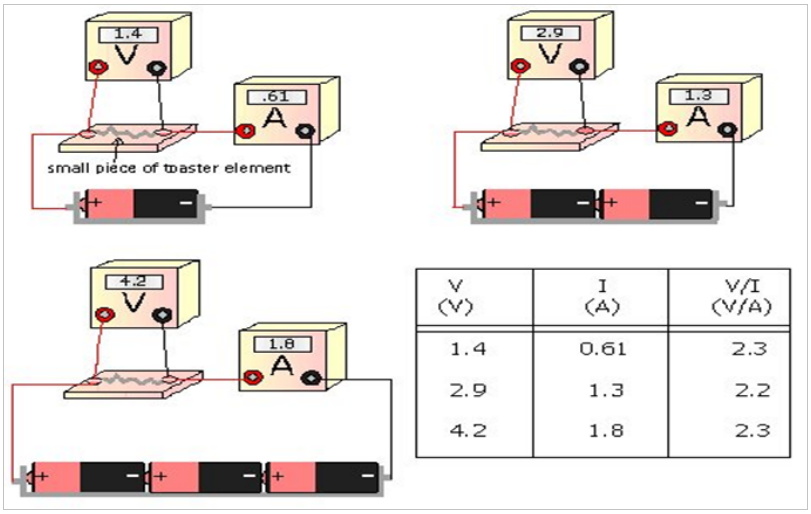
## Section 6: Introduction to Resistance

### Recall:

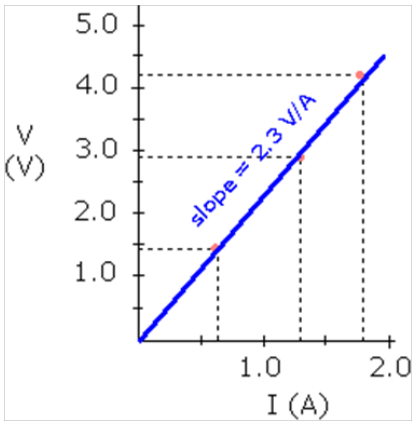
Voltage or potential difference ($V$) may be thought of as the force behind the current ($I$). Thinking of voltage as a force suggests that the larger the voltage of a source, the more current will be pushed through the circuit. Large $V$ means large $I$. **To make that last statement it is assumed that the resistance of the path doesn't change.**

To investigate the relation between the Voltage (or Potential Difference) and the rate of current flow, we can apply different potentials across a toaster element, a resistor, and monitor the corresponding currents that result.

The picture below shows 3 circuits. One, two and three 1.5 V cells are connected in series with a small piece of toaster element mounted on a piece of wood. An ammeter and a voltmeter give the current and voltage readings for each set-up. These measurements are also tabulated in the accompanying table.




| V (V) | I (A) | V/I (V/A) |
|---|---|---|
| 1.4 | 0.61 | 2.3 |
| 2.9 | 1.3 | 2.2 |
| 4.2 | 1.8 | 2.3 |




$V \propto I$

Note that *V* vs. *I* is a straight line which means that for this particular circuit element the ratio of potential difference to the current is constant. This **ratio** (which can be found by calculating the slope) is referred to as the **resistance**. The **slope** or **resistance of this element is** 2.3 V/A or 2.3 Ω.

The SI unit of resistance is the ohm and uses the Greek symbol omega, "Ω".

A resistance of 1 Ω means that a potential difference of 1 V applied across the ends of the device will sustain a current of 1 ampere. 10 Ω of resistance means that a potential difference of 10 V is necessary to sustain a current of 1A.

**This is Ohm's Law,** $R = \frac{V}{I}$ $\frac{V}{A} = \frac{J/C}{C/S} = \frac{J}{C} \times \frac{S}{C} = \frac{JS}{C^2}$

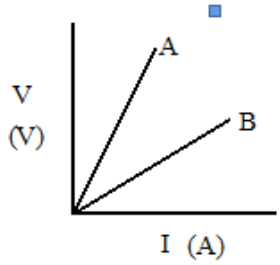
where: **R** is called the resistance in ohms ( Ω ) and it depends on the particular conductor. 1 Ω = 1V /1A

**V** is the potential difference in volts ( **V** )

**I** is the current in amperes ( **A** )

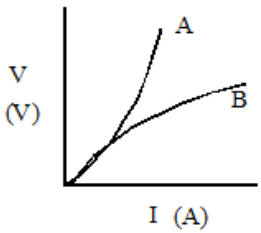
**Ohm's Law**:
**The current in a circuit is directly proportional to the voltage applied as long a the resistance in the circuit does not change.**

A **linear** or **ohmic resistor** is one for which the graph of Voltage (V) versus Current (I) is a straight line. The slope of the line is the resistance; the greater the slope, the greater the resistance.

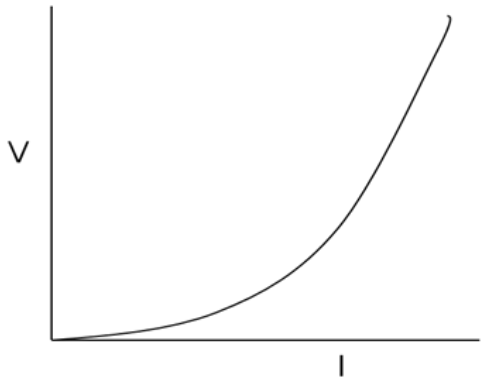



A has the greater resistance.

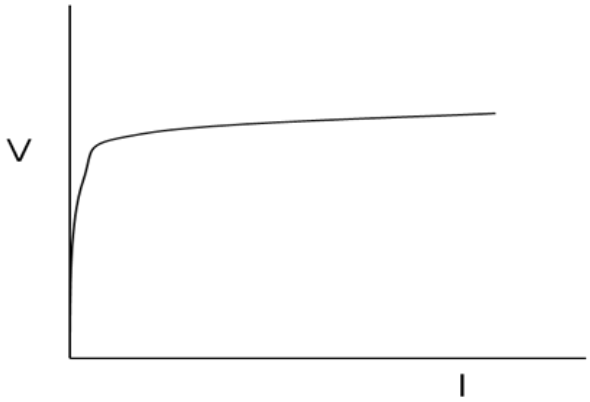
A **non-linear** or **non-ohmic** resistor is one for which the graph of Voltage (V) versus Current (I) is a curve.



## Non-ohmic Circuit Elements




This graph is typical of a light bulb. Resistance increases as the filament heats up.




This graph is typical of a diode, a semi-conductor. Under lower voltages it behaves very much like an insulator. Then, when the voltage is right it "cuts in" and acts conductor!

**Rearrangements of the Formula:** $R = \frac{V}{I}$

$V = IR$

$V \propto I$, if $R$ is constant ✓

$V \propto R$, if $I$ is constant

$I \propto \frac{1}{R}$ if $V$ is constant ✓

**Examples:**

1. A 30 V battery maintains current through a 10 Ω resistor. What is the current?

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

$I = \frac{V}{R} = \frac{30V}{10\Omega} = 3A$

2. A 12 V battery is connected to a device and 24 mA of current flows through it. If the device obeys Ohm's Law, how much current will flow when a 24 V battery is used?

$V_1 = 12V$ $V_2 = 24V$

$I_1 = 24mA$ $I_2 = ?$

$R = ?$ → same

① * Ohm's Law states $V \propto I$ if R is constant

∴ if V is doubled, I is doubled

∴ $I = 48mA$

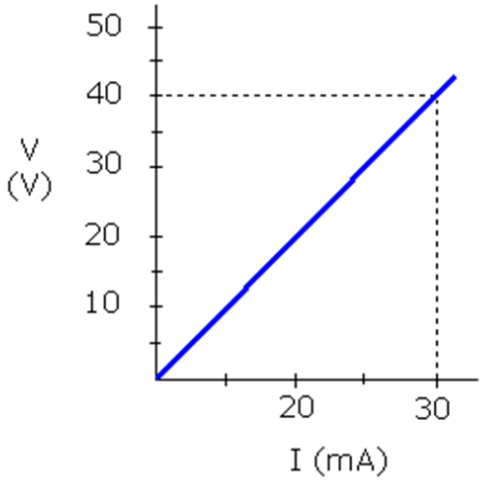
② If the device obeys ohm's law, then R is constant. So, we can find R first.

3. An FRS radio is operated by 4 AA cells. If the device has a resistance of 26.8 Ω, what current does the device draw?

# Test yourself

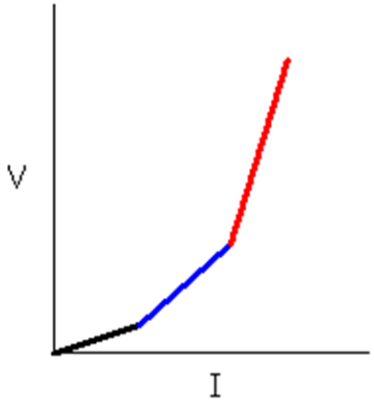
1. The graph below results when a variable voltage source is placed across a substance of unknown resistance and the current is measured for different applied voltages. What is value of the resistance?

- a) 1.3 Ω
- b) 0.75 Ω
- c) 1300 Ω
- d) 750 Ω




2. Which is the most sensible statement regarding the graph below?

- a) 3 different voltages were applied
- b) the resistance in the circuit became larger as the current increased
- c) the resistance in the circuit has an infinite number of values
- d) three different currents were measured



3. Which of the following is not an expression of Ohm's Law?

- a) I = R/V
- b) V = IR
- c) V = RI
- d) R = V/I

4. In a certain circuit V = v, I = i and R = r. What will be the value of the current if the voltage is doubled and the resistance tripled?

- a) i
- b) (2/3) i
- c) (3/2) i
- d) 3v/2r