

# Electronics

## Resistors and Resistance

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February 16, 2010

In this document, you'll learn:

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- what **voltage, current, and resistance** mean

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- how to measure them

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Current, Resistance, and Voltage  
Water analogy  
Ohm's Law  
Resistors and Measuring Resistance  
Ground  
Circuits  
Power

Current  
Resistance  
Voltage

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By convention, the direction of current flow in a circuit is opposite to the direction of electron flow (*Blame Benjamin Franklin.*)

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$k\Omega$  ( $10^3$  ohms) or  $M\Omega$  ( $10^6$  ohms) are common.

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- Measured in volts using a voltmeter

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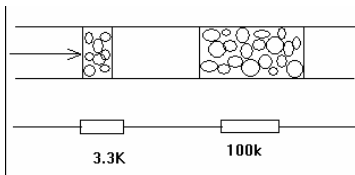
- measured *across a device* or *between two points*;  
(it is a “difference”)
- if measured at a *point* in a circuit, that means it is measured between the point and *ground*



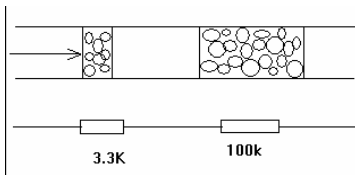
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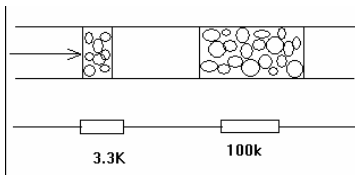


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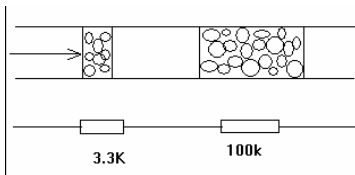
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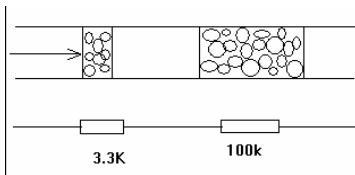
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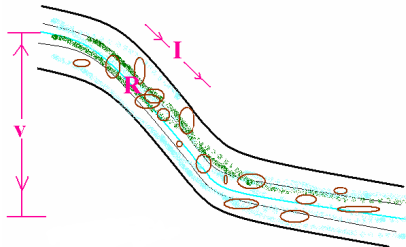


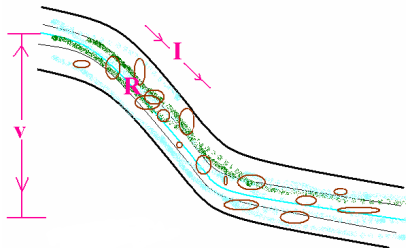
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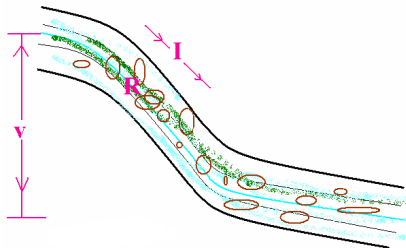
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- wires → large smooth pipes carrying water current
- resistors → narrow or obstructed pipes which limit current





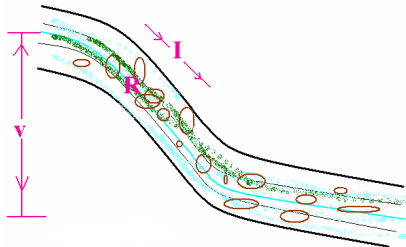
If we want to increase the water flow we can:





If we want to increase the water flow we can:

- increase the water pressure



If we want to increase the water flow we can:

- increase the water pressure
- use less rocks or widen the pipe

If we want to increase the current in a circuit we can:

If we want to increase the current in a circuit we can:

- increase the voltage

If we want to increase the current in a circuit we can:

- increase the voltage
- lower the resistance

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- An **ohmic device** is one for which the ratio between voltage and current is constant; i.e. it doesn't depend on the voltage
- A **non-ohmic device** is one for which the ratio between voltage and current is *not* constant; i.e. it depends on the voltage

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Current and voltage must be measured with power applied to the circuit

# Resistors in Circuit Diagrams

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## Resistor symbols

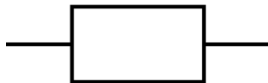


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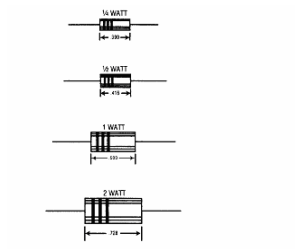
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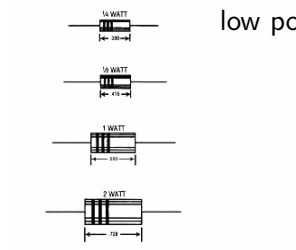


North American



European





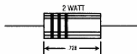
low power; 1/4 W



low power;  $1/4$  W



medium power;  $1/2$  W

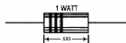




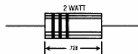
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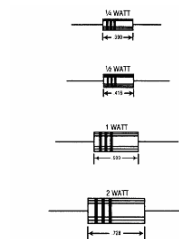


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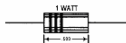
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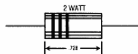
low power;  $1/4$  W



medium power;  $1/2$  W



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Higher power resistors are bigger so they can dissipate more heat.

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- Measure resistance based on ohm's law using the voltage across the resistor and the current passing through it.

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- Measure resistance based on ohm's law using the voltage across the resistor and the current passing through it.
- The most reliable measurement will be with the resistor removed from any circuit.

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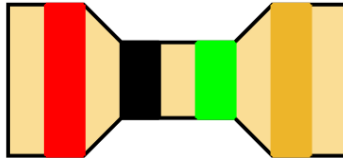
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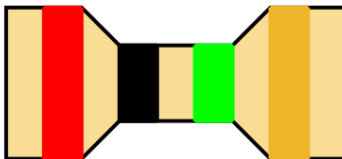
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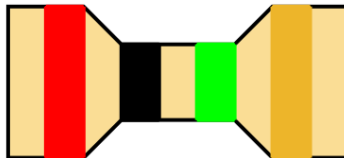
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- **Wrong** (White - 9)

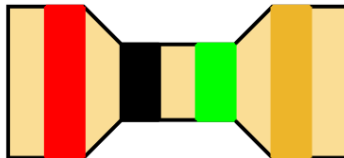




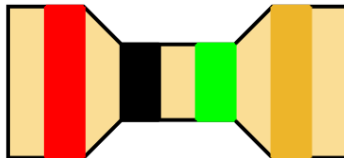
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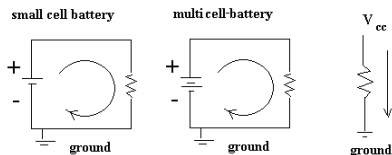
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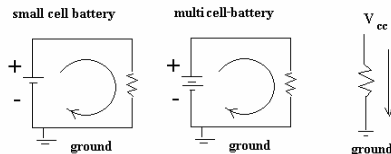
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(i.e all voltages can be relative to this)

# Circuits



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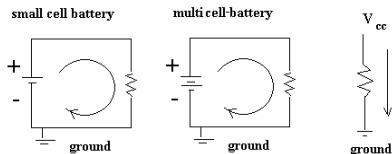
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