Resistance

Resistor

The electrical resistance of a circuit component or device is defined as the ratio of the voltage applied to the electric current which flows through it:

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

If the resistance is constant over a considerable range of voltage, then Ohm's law, I = V/R, can be used to predict the behavior of the material. Although the definition above involves DC current and voltage, the same definition holds for the AC application of resistors.

Whether or not a material obeys Ohm's law, its resistance can be described in terms of its bulk resistivity. The resistivity, and thus the resistance, is temperature dependent. Over sizable ranges of temperature, this temperature dependence can be predicted from a temperature coefficient of resistance.

Conductors and insulators	Resistor combinations	Non-ohmic resistance: the electric pickle

AC behavior of resistor	Common carbon resistors

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DC Circuits

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Resistivity and Conductivity

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The electrical resistance of a wire would be expected to be greater for a longer wire, less for a wire of larger cross sectional area, and would be expected to depend upon the material out of which the wire is made. Experimentally, the dependence upon these properties is a straightforward one for a wide range of conditions, and the resistance of a wire can be expressed as

$$R = \frac{\rho L}{A}$$

ρ = resistivity
L = length
A = cross sectional area

The factor in the resistance which takes into account the nature of the material is the resistivity . Although it is temperature dependent, it can be used at a given temperature to calculate the resistance of a wire of given geometry.

It should be noted that it is being presumed that the current is uniform across the cross-section of the wire, which is true only for Direct Current. For Alternating Current there is the phenomenon of "skin effect" in which the current density is maximum at the maximum radius of the wire and drops for smaller radii within the wire. At radio frequencies, this becomes a major factor in design because the outer part of a wire or cable carries most of the current.

The inverse of resistivity is called conductivity. There are contexts where the use of conductivity is more convenient.

$$\text{Electrical conductivity} = \sigma = 1/\varrho$$

Calculation	Table of resistivities	Common wire gauges

Microscopic view of resistivity

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Resistor Combinations

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DC Circuits

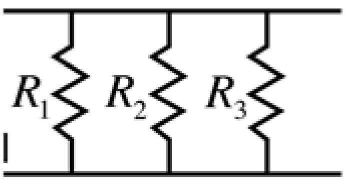
The combination rules for any number of resistors in series or parallel can be derived with the use of Ohm's Law, the voltage law, and the current law.

Series

$$\boxed{R_{equivalent} = R_1 + R_2 + R_3 + \ldots}$$

$$R_{equivalent} = \frac{V}{I} = \frac{V_1 + V_2 + V_3 + \ldots}{I} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3} + \ldots = R_1 + R_2 + R_3 + \ldots$$

Series key idea: The current is the same in each resistor by the current law.



Parallel

$$\boxed{\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

Parallel:

$$\frac{V}{R_{equivalent}} = I = I_1 + I_2 + I_3 + \ldots = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \ldots$$

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Parallel key idea: The voltage is the same across each resistor by the voltage law.

Comparison example

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Resistivity Calculation

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The electrical resistance of a wire would be expected to be greater for a longer wire, less for a wire of larger cross sectional area, and would be expected to depend upon the material out of which the wire is made (resistivity). Experimentally, the dependence upon these properties is a straightforward one for a wide range of conditions, and the resistance of a wire can be expressed as

$$R = \frac{\rho L}{A}$$

Resistance = resistivity x length/area

For a wire of length **L** = [ ] m = [ ] ft
and area **A** = [ ] cm^2
corresponding to radius **r** = [ ] cm
and diameter [ ] inches for common wire gauge comparison
with resistivity = ρ = [ ] x 10^ [ ] ohm meters
will have resistance **R** = [ ] ohms.

Enter data and then click on the quantity you wish to calculate in the active formula above. Unspecified parameters will default to values typical of 10 meters of #12 copper wire. Upon changes, the values will not be forced to be consistent until you click on the quantity you wish to calculate.

Commonly used U.S. wire gauges for copper wire.

AWG	Diameter (inches)	Typical use
10	0.1019	Electric range
12	0.0808	Household circuit
14	0.0640	Switch leads

Standard wire gauges

Resistivities of some metals in ohm-m(x 10^{-8}) at 20°C.

Aluminum	2.65	Gold	2.24
Copper	1.724	Silver	1.59
Iron	9.71	Platinum	10.6
Nichrome	100	Tungsten	5.65

Table of resistivities

The factor in the resistance which takes into account the nature of the material is the resistivity. Although it is temperature dependent, it can be used at a given temperature to calculate the resistance of a wire of given geometry.

Discussion | Table of resistivities | Common wire gauges

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