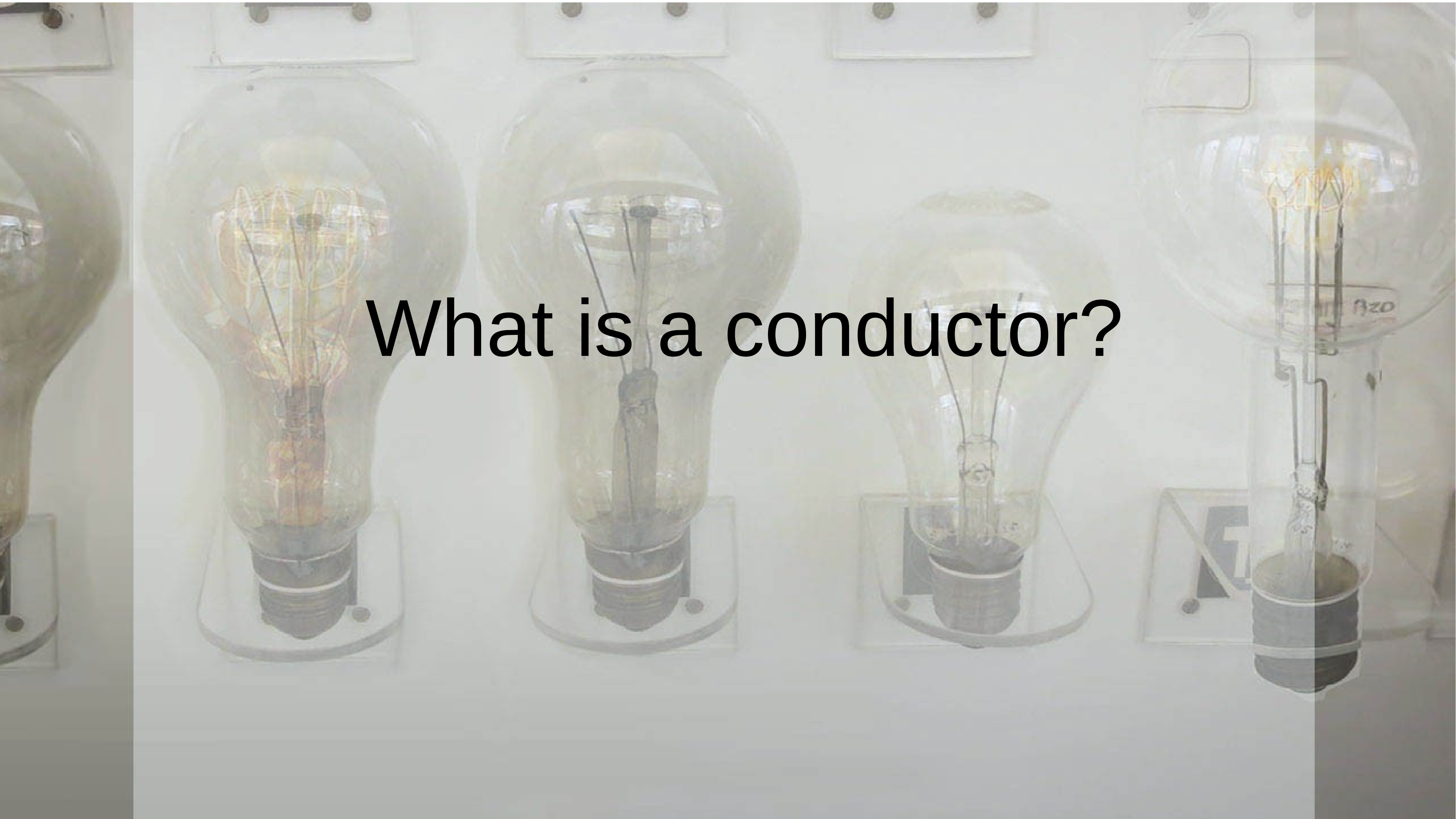
Introductory Concepts Pt 2:

More details about circuits

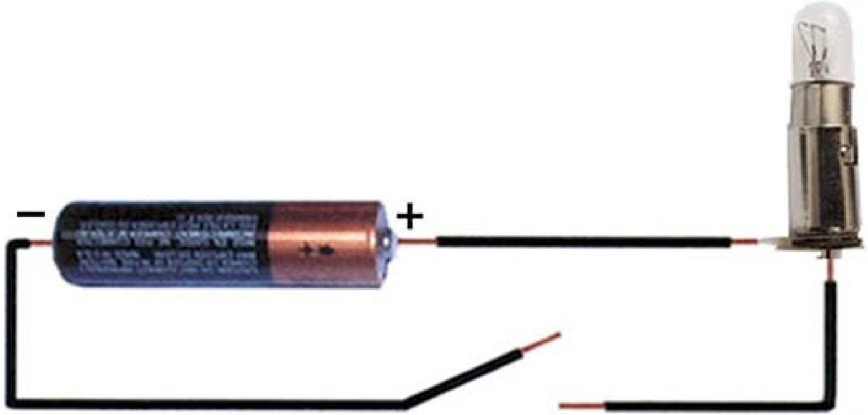
What is a conductor?



Materials that have lots of “free electrons” in their atomic structure that move easily from and between their valence shells are referred to as **conductors** (e.g. copper, gold.) Conversely, materials with relatively few free electrons are called **insulators** (e.g. wood, rubber.) If the electromotive potential is great enough, just about anything can become a conductor, even the air in the sky (in the case of lightning.)

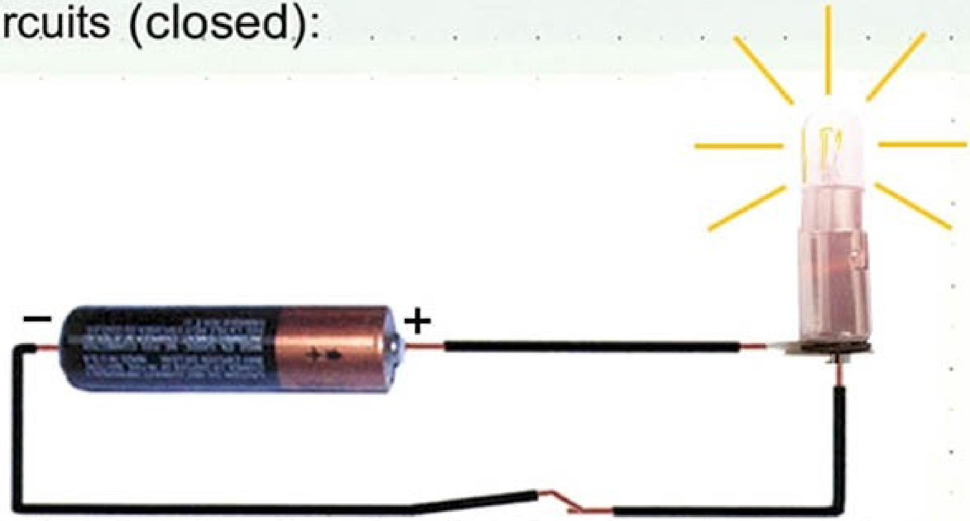
Electrons don't have to travel the entire length of a circuit in order for electrical conductance to happen.

Simple DC Circuits (open):



Here is perhaps the simplest circuit we could build. In this case the light bulb is the “load” in the circuit, controlled by a “single pole, single throw” (SPST) switch. (More about switches later.)

Simple DC Circuits (closed):



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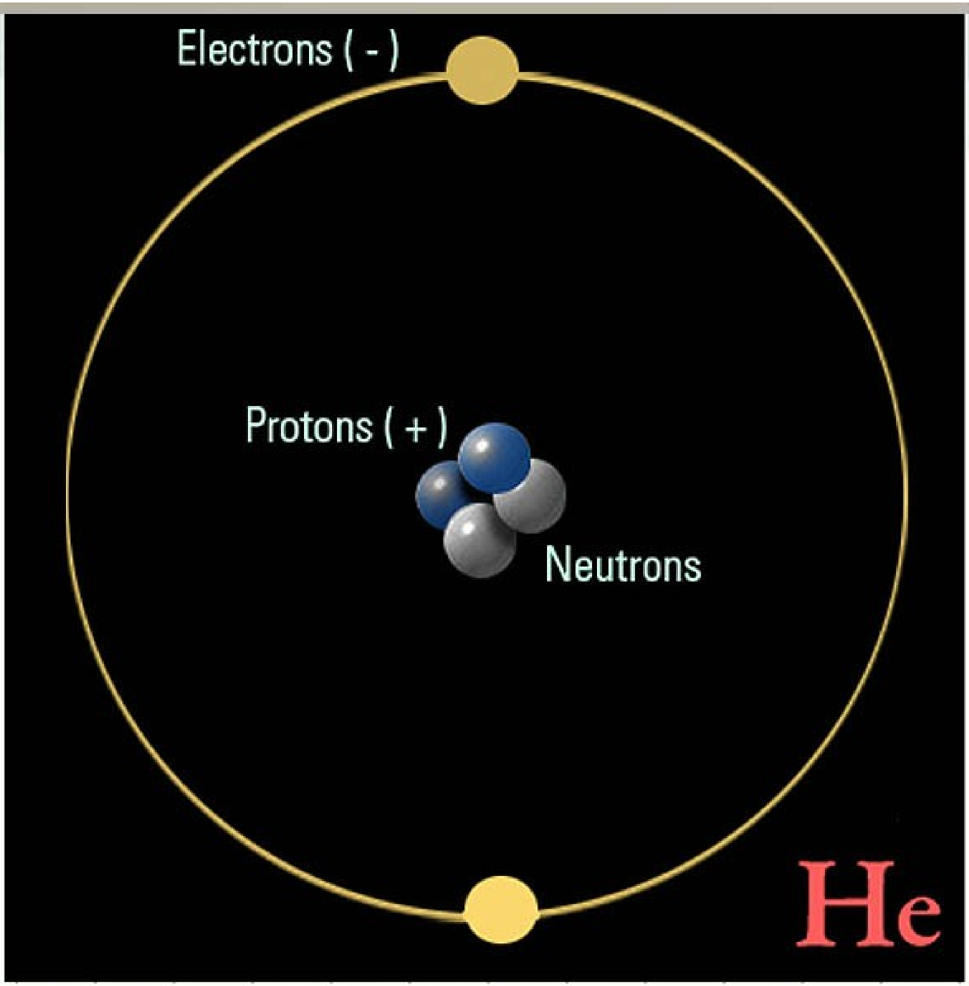
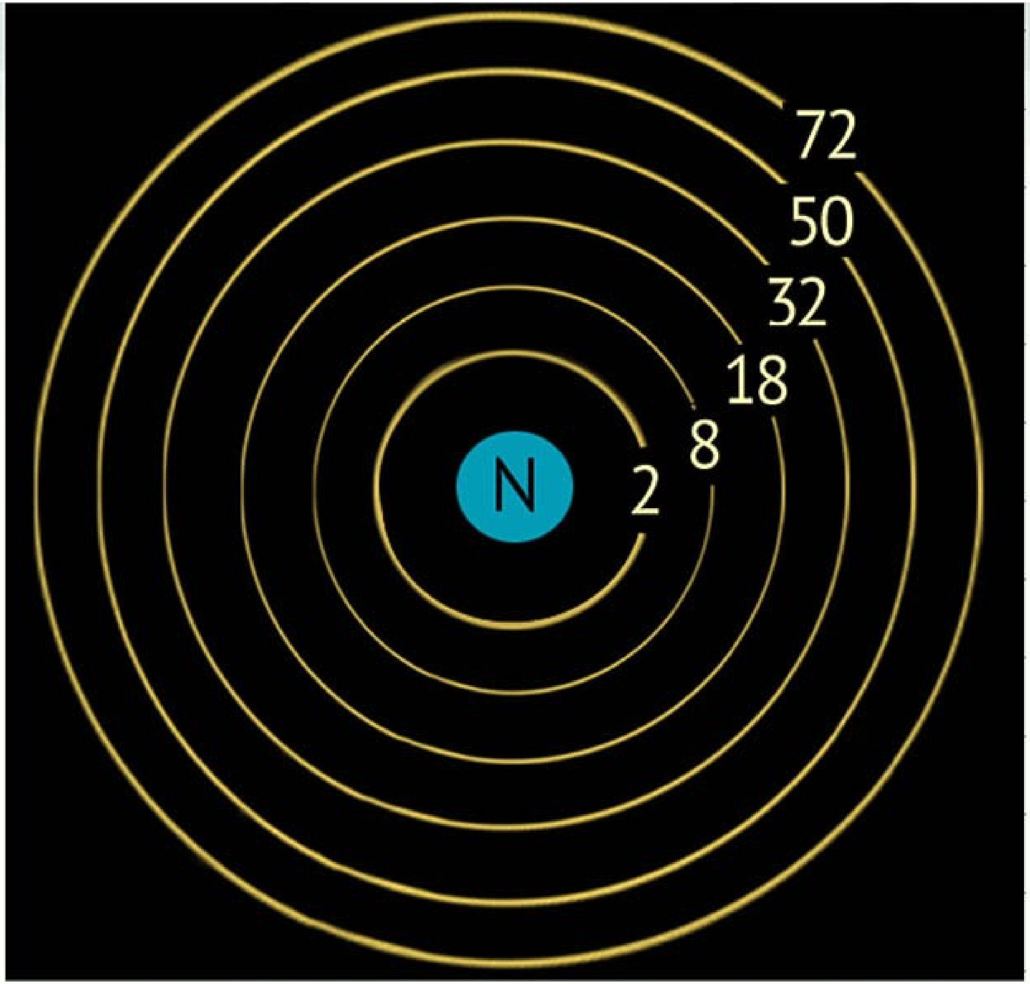


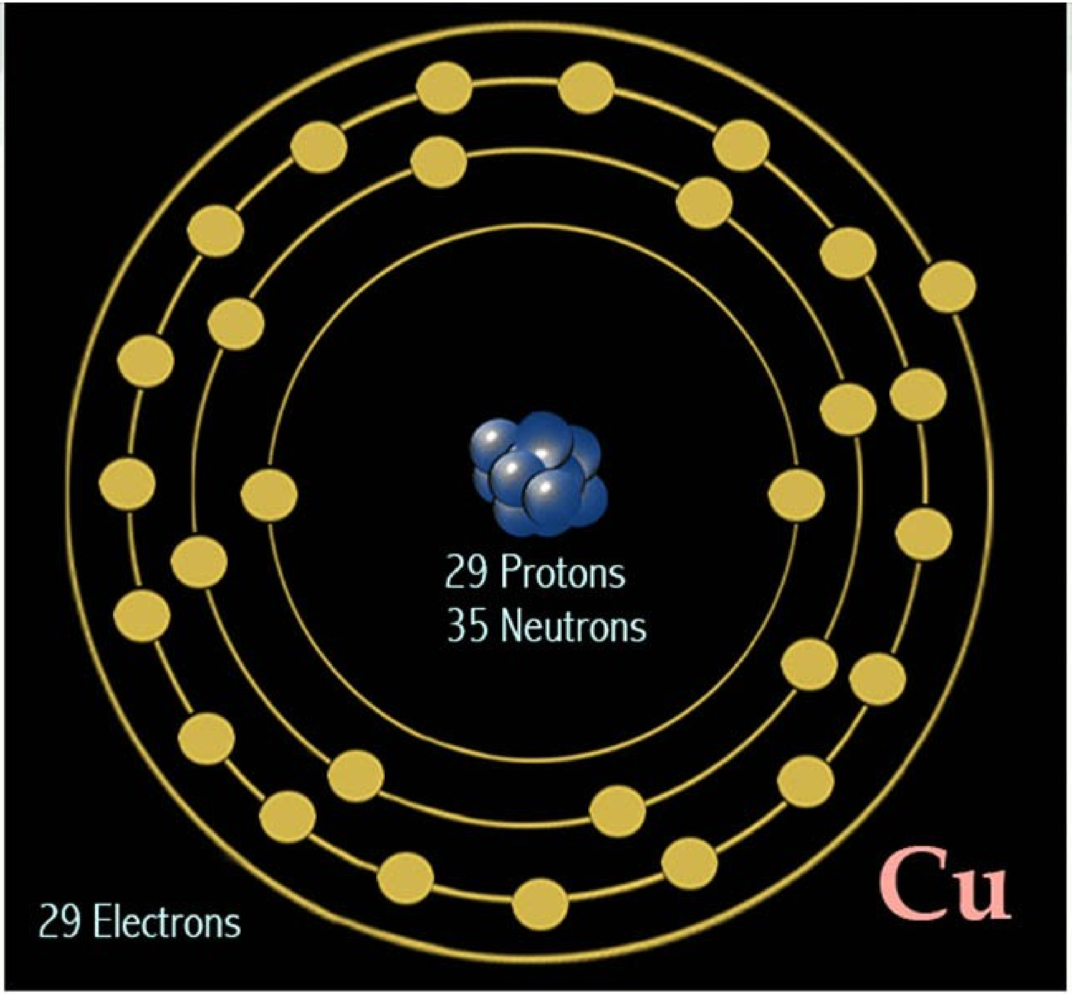
Helium atom:

2 Protons,
2 Neutrons
2 Electrons

The classic "Rutherford-Bohr" model of the atom.
Niels Bohr developed it in 1913. It has since had numerous amendments to account for discoveries in *quantum mechanics*.

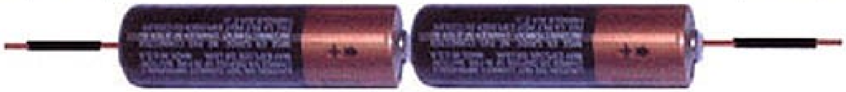


Bohr discovered that electrons could only exist in specific “quantized” orbits, with only a certain number of electrons allowed in each orbit or “shell”. The outer “valence” shell was key in how the atom interacted with other atoms.



The element copper has 29 electrons in 4 energy level, with only ***one lonely electron*** in it's fourth (outer) shell.

Series and Parallel:



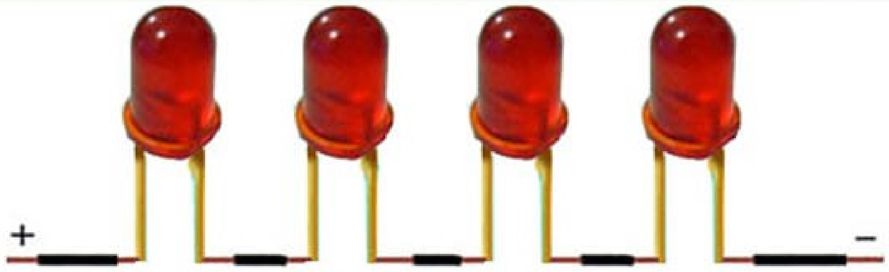
Batteries in series.

When connected "in series", DC voltage sources are <u>added</u>. In the above example, two AA batteries (1.5 volts each) wired in series supply 3 volts to the circuit. (1.5 + 1.5 = 3.)

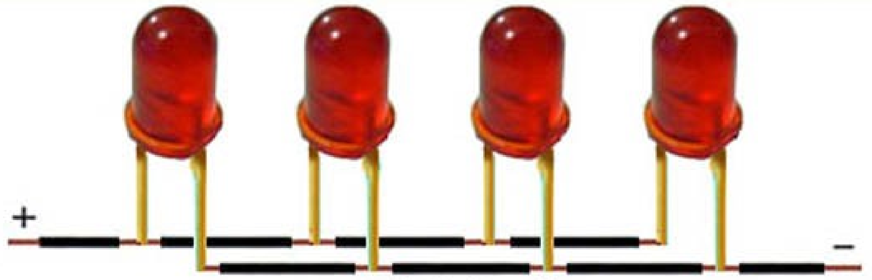
Batteries in parallel.

When connected "in parallel", batteries' voltages are unaffected, but the current (measured in *amperes*) is increased. In the above example, two AA batteries (1.5 volts each) wired in parallel supply 1.5 volts to the circuit, but can do so for a longer time than a single battery alone.

Series and Parallel load:



series circuit



parallel circuit

The concept of being “in series” or “parallel” also applies to electrical components which are wired as the load of the circuit.

What's going on inside a resistor?

If you break one open, and scratch off the outer coating of insulating paint, you might see an insulating ceramic rod running through the middle with copper wire wrapped around the outside. A resistor like this is described as wire-wound. The number of copper turns controls the resistance very precisely: the more copper turns, and the thinner the copper, the higher the resistance.

In smaller-value resistors, designed for lower-power circuits, the copper winding is replaced by a spiral pattern of carbon. Resistors like this are much cheaper to make and are called carbon-film. Generally, wire-wound resistors are more precise and more stable at higher operating temperatures.

Resistor Color Codes

Resistance values:

- 0 = Black
- 1 = Brown
- 2 = Red
- 3 = Orange
- 4 = Yellow
- 5 = Green
- 6 = Blue
- 7 = Violet
- 8 = Grey
- 9 = White

Tolerance values

- Brown ± 1%
- Red ±2%
- Gold ±5%
- Silver ± 10%

On most resistors, you'll see there are three rainbow-colored bands, then a fourth band usually colored gold, or silver.

The first two of the rainbow bands tell you the first two digits of the resistance. Suppose you have a resistor like the one shown here, with colored bands that are brown, black, and red and a fourth golden band. You can see from the color chart below that brown means 1 and black means 0, so the resistance is going to start with "10". The third band is a decimal multiplier: (how many zeros to add on the end.) Red means 2, so we multiply the 10 we've got already by 10 × 10 = 100 and get 1000. Our resistor is 1000 ohms. (...which we call a "1k.")

Prefixes:

These prefixes are universally used to scale units in science and engineering:

Prefix	*Abbreviation*	*Multiplier*
tera	T	10^{12} (= 1,000,000,000,000)
giga	G	10^{9} (= 1,000,000,000)
mega	M	10^{6} (= 1,000,000)
kilo	k	10^{3} (= 1,000)
(none)	*(none)*	10^{0} (= 1)
centi	c	10^{-2} (= 0.01)
milli	m	10^{-3} (= 0.001)
micro	μ	10^{-6} (= 0.000 001)
nano	n	10^{-9} (= 0.000 000 001)
pico	p	10^{-12} (= 0.000 000 000 001)
femto	f	10^{-15} (= 0.000000000000001)

When abbreviating a unit with a prefix, the symbol for the unit follows the prefix without space. Be careful about upper-case and lower-case letters (especially m and M.) 1mW is a milliwatt, or one-thousandth of a watt, but 1MW is a megawatt (one million watts.) The unit name is only capitalized when it is abbreviated. For example, in describing cycles-per-second we use hertz and kilohertz, but Hz and kHz.