***Resistivity:*** We consider short lengths of conductors to have essentially zero resistance, but this is not true for long lengths. The resistance of a conductor is given by this equation:

|  |  |
| --- | --- |
| Resistivities of Common Materials | |
| Material  Silver  Copper  Gold  Aluminum  Tungsten  Iron  Platinum  Lead  Nichrome  Carbon  Germanium  Silicon  Glass  Hard Rubber  Sulfur  Quartz | Resistivity  (Ω⋅m)  1.59 x 10 - 8  1.70 x 10 - 8  2.44 x 10 – 8  2.82 x 10 - 8  5.60 x 10 - 8  10.0 x 10 - 8  11.0 x 10 - 8  22.0 x 10 - 8  150 x 10 - 8  3.50 x 10 5  0.46  640  1010 - 1014  1013  1015  75 x 1016 |



***R*** is the resistance, ***ρ*** is the resistivity of the conductor, ***l*** is the length of the conductor, and ***A*** is the cross sectional area of the conductor.

This equation is only good for wires that have a constant cross-section.

The resistivity depends on the metal, each metal has it own value. Generally you look the thing up when you want to do a problem.

The longer the wire, the greater its resistance will be. What about the size of the wire; its diameter? You can see from the equation that as the cross sectional area of the wire increases, the resistance will decrease. So a thick fat wire will have less resistance than a very thin one will.

Interesting. Think of it this way, in a big fat wire there are lots of paths for the electrons to go through. In a skinny wire, there aren’t as many paths and the electrons are sort of scrunched together trying to get through, so they get held up more. This means more resistance.

If you look at the table of resistivity values, you see that the best conductor is silver with copper coming in a close second. Silver, great conductor that it is, is quite expensive, so copper is the conductor of choice when wiring things together.

Gold is sometimes used, not because it is the best conductor, which, from the table, you can see, but rather because it is pretty inert stuff and doesn’t react with its surroundings or corrode. Copper is quite happy to corrode. So electrical connections with copper wire that is exposed to the elements can corrode. That wouldn’t happen with gold.

Here is a lovely model of electricity flowing through a circuit.

We have a coal mine which puts 100 tons of coal into each car that goes through. The cars come in empty, they leave with coal. The mine represents the voltage source. Each car receives 100 tons of “potential energy”. This is equivalent of the energy provided by a battery.

The train travels along the track, which represents the conductor in a circuit.

As the cars travel along they pass through a car rate meter which measures the number of cars that pass in a minute. This represents the current, which is the number of Coulombs of charge per second. Here we have a rate of 5 cars/minute.

The next thing the train must travel through is a coal detector. This is the gizmo represented by This device measures the amount of coal in each car going in and out and measures the difference. For the first one, the tons of coal in each car are the same going in as coming out. This meter represents the voltmeter, which measures potential difference across a component. There is no potential difference in a short piece of conductor just as there is no difference in the amount of coal in each car traveling along the straight track.

The coal arrives at a power plant. This, the power plant, represents the load. Each car dumps the 100 tons of coal it began with. There is a coal mass difference across the plant of 100 tons per car. This represents the voltage drop of the load.

After the power plant, once again there is no mass difference between the cars. Also the car rate is still the same, 5 cars/minute.

Back at the mine, there is a mass difference as the cars go into the mine and leave the mine of 100 tons per car. This represents the voltage drop across the battery.

What a lovely little model. Is everything clear? What if there were 2 power plants?

* What is the resistance of a copper wire, which has a diameter of 1.00 mm and a length of 12.2 m? The resistivity of copper is 1.7 x 10-8 Ω⋅m. All we have to do is plug and chug.

* A square aluminum rod is 1.0 meters long and 5.0 mm on each side. What is the resistance between its ends? What must be the length of one side of a square copper rod if its resistance is to be the same?
* After a meteorite lands on Earth a new metallic substance Lawsonium is discovered. A cubic sample with a width of 3.0 mm is extracted from the meteorite and placed in a simple series circuit with a 9.0 V battery. In this simple setup, the current was measured at 2.0 A. Find the resistivity of Lawsonium.