Another way to find resistance

The ______________ varies ______________ with ______________ and ______________ with ______________ (or cross-sectional ______________) a wire

- Short, thick wire → ______________ resistance
- Long, skinny wire → ______________ resistance

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

  - ρ = ______________ (Unit: Ωm)
- Table 20.1 lists resistivities of some materials
  - Metals → ______________ resistivity (1×10^{-8} Ω m)
  - Insulators → ______________ resisitivity (1×10^{15} Ω m)
  - Semi-conductors → ______________ resistivity

Table 20.1 Resistivities ρ of Various materials at 20°C

Material	Resistivity ρ (Ω · m)
Conductors	
Silver	1.59×10^{-8}
Copper	1.72×10^{-8}
Gold	2.44×10^{-8}
Aluminum	2.65×10^{-8}
Tungsten	5.6×10^{-8}
Iron	9.71×10^{-8}
Platinum	10.6×10^{-8}
Steel	20×10^{-8}
Lead	22×10^{-8}
Manganin (Cu, Mn, Ni alloy)	44×10^{-8}
Constantan (Cu, Ni alloy)	49×10^{-8}
Mercury	96×10^{-8}
Nichrome (Ni, Fe, Cr alloy)	100×10^{-8}
Semiconductors[1]	
Carbon (pure)	3.5×10^{5}
Carbon	$(3.5-60)\times10^{5}$
Germanium (pure)	600×10^{-3}
Germanium	$(1-600)\times10^{-3}$
Silicon (pure)	2300
Silicon	0.1–2300
Insulators	
Amber	5×10^{14}
Glass	$10^{9}-10^{14}$
Lucite	$>10^{13}$
Mica	$10^{11}-10^{15}$
Quartz (fused)	75×10^{16}
Rubber (hard)	$10^{13}-10^{16}$
Sulfur	10^{15}
Teflon	$>10^{13}$
Wood	$10^{8}-10^{11}$

Why are long wires thick?

Wire thicknesses are measured in gauges. 20-gauge wire is thinner than 16-gauge wire. If 20-gauge wire has $A = 5.2 \times 10^{-7}\ m^2$ and 16-gauge wire has $A = 13 \times 10^{-7}\ m^2$, find the resistance per meter of each if they are copper.

Table 20.2 Tempature Coefficients of Resistivity α

Material	Coefficient α (1/°C)[2]
Conductors	
Silver	3.8×10^{-3}
Copper	3.9×10^{-3}
Gold	3.4×10^{-3}
Aluminum	3.9×10^{-3}
Tungsten	4.5×10^{-3}
Iron	5.0×10^{-3}
Platinum	3.93×10^{-3}
Lead	3.9×10^{-3}
Manganin (Cu, Mn, Ni alloy)	0.000×10^{-3}
Constantan (Cu, Ni alloy)	0.002×10^{-3}
Mercury	0.89×10^{-3}
Nichrome (Ni, Fe, Cr alloy)	0.4×10^{-3}
Semiconductors	
Carbon (pure)	-0.5×10^{-3}
Germanium (pure)	-50×10^{-3}
Silicon (pure)	-70×10^{-3}

Resistivity and Temperature

$$\rho = \rho_0(1 + \alpha\Delta T)$$

- ρ = resistivity at temperature T
- ρ_0 = resistivity at temperature T_0
- α = temperature coefficient of resistivity (Unit: 1/°C (or 1/K))

Metals

- Resistivity ___________ with temperature
- α is ______________

Semiconductors

- Resistivity ___________ with temperature
- α is ______________

Resistance and Temperature

$$R = R_0(1 + \alpha\Delta T)$$

- R = resistance at temperature T
- R_0 = resistance at temperature T_0
- α = temperature coefficient of resistivity (Unit: 1/°C (or 1/K))

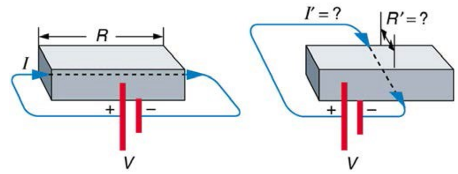
A heating element is a wire with cross-sectional area of 2×10^{-7} m^2 and is 1.3 m long. The material has resistivity of 4×10^{-5} Ωm at 200°C and a temperature coefficient of 3×10^{-2} 1/°C. Find the resistance of the element at 350°C.

Superconductors

- Materials whose _______________ = _______________
- _______________ become superconductors at _______________ _______________ temperatures
  - Some materials using _______________ _______________ work at much _______________ temperatures
- No current _______________
- Used in
  - Transmission of _______________, _______________, _______________, Powerful, small electric motors, Faster _______________ chips

Homework

1. In which of the three semiconducting materials listed in Table 20.1 do impurities supply free charges? (Hint: Examine the range of resistivity for each and determine whether the pure semiconductor has the higher or lower conductivity.)



2. Does the resistance of an object depend on the path current takes through it? Consider, for example, a rectangular bar—is its resistance the same along its length as across its width? (See Figure.)
3. If aluminum and copper wires of the same length have the same resistance, which has the larger diameter? Why?
4. What is the resistance of a 20.0-m-long piece of 12-gauge copper wire having a 2.053-mm diameter? (OpenStax 20.24) **0.104 Ω**
5. The diameter of 0-gauge copper wire is 8.252 mm. Find the resistance of a 1.00-km length of such wire used for power transmission. (OpenStax 20.25) **0.322 Ω**
6. If the 0.100-mm diameter tungsten filament in a light bulb is to have a resistance of 0.200 Ω at 20.0 °C, how long should it be? (OpenStax 20.26) $\mathbf{2.81 \times 10^{-2}\ m}$
7. What current flows through a 2.54-cm-diameter rod of pure silicon that is 20.0 cm long, when 1.00×10^3 V is applied to it? (Such a rod may be used to make nuclear particle detectors, for example.) (OpenStax 20.28) $\mathbf{1.10 \times 10^{-3}\ A}$
8. (a) To what temperature must you raise a copper wire, originally at 20.0 °C, to double its resistance, neglecting any changes in dimensions? (b) Does this happen in household wiring under ordinary circumstances? (OpenStax 20.29) **276 °C**
9. A resistor made of Nichrome wire is used in an application where its resistance cannot change more than 1.00% from its value at 20.0 °C . Over what temperature range can it be used? (OpenStax 20.30) **−5°C to 45 °C**
10. Of what material is a resistor made if its resistance is 40.0% greater at 100 °C than at 20.0 °C? (OpenStax 20.31) $\mathbf{5.00 \times 10^{-3}\ /°C}$
11. (a) Of what material is a wire made, if it is 25.0 m long with a 0.100 mm diameter and has a resistance of 77.7 Ω at 20.0 °C? (b) What is its resistance at 150 °C? (OpenStax 20.33) $\mathbf{1.1 \times 10^{2}\ \Omega}$
12. (a) Digital medical thermometers determine temperature by measuring the resistance of a semiconductor device called a thermistor (which has α = −0.0600 /°C) when it is at the same temperature as the patient. What is a patient's temperature if the thermistor's resistance at that temperature is 82.0% of its value at 37.0 °C (normal body temperature)? (OpenStax 20.37a) **40.0 °C**