Another way to find resistance

The resistance varies __________ with __________ and __________ with __________ (or cross-sectional __________) a wire.
- Short, thick wire → __________ resistance
- Long, skinny wire → __________ resistance
  \[ R = \frac{\rho L}{A} \]
  - \( \rho = \_________________ \) (Unit: \( \Omega \text{m} \))
- Table 20.1 lists resistivities of some materials
  - Metals \( \rightarrow \) __________ resistivity \( (1 \times 10^{-8} \Omega \text{m}) \)
  - Insulators \( \rightarrow \) __________ resistivity \( (1 \times 10^{15} \Omega \text{m}) \)
  - Semi-conductors \( \rightarrow \) __________ resistivity

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 \( A = 5.2 \times 10^{-7} \text{m}^2 \) and 16-gauge wire has \( A = 13 \times 10^{-7} \text{m}^2 \), find the resistance per meter of each if they are copper.

Resistivity and Temperature

\[ \rho = \rho_0(1 + \alpha \Delta T) \]
- \( \rho = \) resistivity at temperature \( T \)
- \( \rho_0 = \) resistivity at temperature \( T_0 \)
- \( \alpha = \) temperature coefficient of resistivity
  (Unit: \( 1/\text{°C} \) (or \( 1/\text{K} \))

Metals
- Resistivity __________ with temperature
- \( \alpha = \______________ \)

Semiconductors
- Resistivity __________ with temperature
- \( \alpha = \______________ \)

Resistance and Temperature

\[ R = R_0(1 + \alpha \Delta T) \]
- \( R = \) resistance at temperature \( T \)
- \( R_0 = \) resistance at temperature \( T_0 \)
- \( \alpha = \) temperature coefficient of resistivity
  (Unit: \( 1/\text{°C} \) (or \( 1/\text{K} \))

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

- Materials whose \( \text{_____________} = \text{_____________} \)
- \( \text{_____________} \) become superconductors at \( \text{_____________} \) \( \text{_____________} \) temperatures
  - Some materials using \( \text{_____________} \) \( \text{_____________} \) work at much \( \text{_____________} \) \( \text{_____________} \) temperatures
- No current \( \text{_____________} \)
- Used in
  - Transmission of \( \text{_____________} \) \( \text{_____________} \) \( \text{_____________} \), Powerful, small electric motors, Faster \( \text{_____________} \) 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—does 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 \text{ \( \Omega \) } \)

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 \text{ \( \Omega \) } \)

6. If the 0.100-mm diameter tungsten filament in a light bulb is to have a resistance of 0.200 \( \Omega \) at 20.0 \( ^\circ \text{C} \), how long should it be? (OpenStax 20.26) \( 2.81 \times 10^{-2} \text{ m} \)

7. What current flows through a 2.54-cm-diameter rod of pure silicon that is 20.0 cm long, when \( 1.00 \times 10^3 \text{ V} \) is applied to it? (Such a rod may be used to make nuclear particle detectors, for example.) (OpenStax 20.28) \( 1.10 \times 10^{-3} \text{ A} \)

8. (a) To what temperature must you raise a copper wire, originally at 20.0 \( ^\circ \text{C} \), to double its resistance, neglecting any changes in dimensions? (b) Does this happen in household wiring under ordinary circumstances? (OpenStax 20.29) \( 276 ^\circ \text{C} \)

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 \( ^\circ \text{C} \). Over what temperature range can it be used? (OpenStax 20.30) \( \text{\(-5^\circ \text{C to 45 ^\circ \text{C}\)}} \)

10. Of what material is a resistor made if its resistance is 40.0\% greater at 100 \( ^\circ \text{C} \) than at 20.0 \( ^\circ \text{C} \)? (OpenStax 20.31) \( 5.00 \times 10^{-3} \text{ /^\circ \text{C}\) }

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 \( \text{\Omega} \) at 20.0 \( ^\circ \text{C} \)? (b) What is its resistance at 150 \( ^\circ \text{C} \)? (OpenStax 20.33) \( 1.1 \times 10^2 \text{ \( \Omega \) } \)

12. (a) Digital medical thermometers determine temperature by measuring the resistance of a semiconductor device called a thermistor (which has \( \alpha = -0.0600 \text{ /^\circ \text{C}\) ) 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 \( ^\circ \text{C} \) (normal body temperature)? (OpenStax 20.37a) \( 40.0 \text{ \( ^\circ \text{C} \) } \)