W11.04

Other Topics in Circuits

Resistivity

1. A 10-gauge wire has a cross sectional area of 5.0 mm^2. Copper has a resistivity of 1.69×10^{-8} Ω·m. What is the resistance of 2 km of solid 10-gauge copper wire?

2. A conducting wire had a diameter of 1.0 mm, a 2.0 m length, and a 50 mΩ resistance. What is the resistivity of the material?

3. Silicon is a semi conductor with a resistivity of 2.5×10^{3} Ω·m in its pure state. How long is a 4.0-mm diameter, cylindrical resistor of pure silicon with a resistance of 1 MΩ?

4. We generally neglect the potential difference along wires and the transfer of energy to thermal energy in them. Check the validity of this using a simple, single loop circuit with an idea battery of emf $\mathcal{E}$ = 12.0 V and a resistor R = 6.00 Ω connected by 20.0-cm copper wires with a radius of 1.00 mm.
   a. What is the potential difference across the resistor?
   b. What is the potential difference across each of the two wire segments?
   c. At what rate is energy lost as thermal energy in the resistor?
   d. At what rate is energy lost as thermal energy in the wire segments?

EMF and terminal voltage

5. A battery with emf $\mathcal{E}$ of 12.0 V delivers a current of 0.10 A when connected to a 100 Ω resistor.
   a. What is the terminal voltage of the battery?
   b. What is the internal resistance of the battery?
   c. By what percentage does the output power differ from the ideal 12-V battery with no internal resistance?

6. A wire of resistance 5.0 Ω is connected to a battery with an emf $\mathcal{E}$ of 2.0 V and an internal resistance of 1.0 Ω. In 2.0 min, how much energy is
   a. transferred from chemical form in the battery,
   b. dissipated as thermal energy in the wire, and
   c. dissipated as thermal energy in the battery?

Household circuits, Fuses, and Circuit Breakers

7. Are household circuits wired in series or parallel? Explain via an example how you know this.

8. An electrical circuit is designed to be used with a 200 V, 15 kW electric motor. The motor is to be protected from surges with a fuse. What is the fuse rating necessary for normal operation?

9. A two-slot toaster draws 720 W of power. How many toasters can be used simultaneously on a circuit with a 20-A circuit breaker without tripping the breaker?

11.04 Key

1. 6.76 Ω
2. 1.96×10^{-8} Ω·m
3. 5×10^{-3} m (5 mm)
4. $R_{wire} = 1.076 \times 10^{-3}$ Ω→ I = 1.9993 A (would be 2 neglecting wires)
   a. 11.996 V
   b. 0.00215 V (each)
   c. 23.983 W
   d. 0.0043 W (each)
5. a. 10 V
   b. 20 Ω
   c. (1 W - 1.44 W)/ (1.44 W) = -30.6 %
6. a. 80 J
   b. 66.7 J
   c. 13.3 J
7. parallel, if a lightbulb burns out, other lights on the circuit do not go out, or something similar.
8. 75 A
9. 3 toasters