14: Ohm's Law

Worksheet 16

1. The copper windings of a motor have a resistance of 43 Ω at 20 °C when the motor is idle. After the motor has run for several hours, the resistance rises to 57 Ω. What is the temperature in Celsius of the windings now? Ignore changes in the dimensions of the windings. The temperature coefficient of resistivity for copper is 4.3E-3 K^{-1}.

2. A 2.7 kW heater element from a dryer has a length of 55 cm. If a 7.8 cm section is removed, what power is used by the now shortened element at 120 V?

3. A certain x-ray tube operates at a current of 7.20 mA and a potential difference of 116 kV. What is its power?

4. When connected with a 120 V power source to create a simple circuit (one loop), a resistor carries a current of 0.470 A. Let's visualize our "solid cylinder" model of our resistor: suppose the resistor has length 0.650 m and radius 0.280 mm.

   A What is the resistance of this resistor?

   B What is the resistivity of the material used to make this resistor?

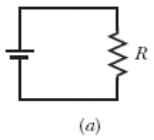
   C What is the current density at all points in this resistor?

   D What is the electric field at all points in this resistor?

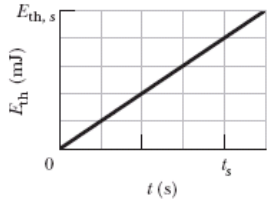
   E At what rate is energy dissipated by the resistor? (in W, recall 1 W = 1 J/s)

5. What is the drift speed of electrons in a copper wire of radius r = 900 μm carrying a uniform current i = 17 mA. (We know $\rho_{copper} = 8.96 \times 10^3$ kg/m^3).

6. In Figure (a), a 44 Ω resistor is connected to a battery. Figure (b) shows the increase of thermal energy E_{th} in the resistor as a function of time t. The vertical scale is set by $E_{th,s}$ = 3.50 mJ, and the horizontal scale is set by t_s = 4.8 s. What is the electric potential across the battery?



(a)



(b)

1 Answers

1. 661.80 W
2. 3.146 kW
3. 835.2 W
4. (a) 255.319 Ω (b) 9.67467E-5 Ω· m (c) 1.908E6 A/m^2 (d) 184.615 N/C (E) 56.4 W
5. 4.9E-7 m/s
6. 0.1602 V