26.1-26.3: Electric current, resistance and resistivity

\[ i = \frac{dq}{dt} \quad i = \int \vec{J} \cdot d\vec{A} \quad i = nAev_d \quad \vec{J} = (ne)v_d \quad \vec{E} = \rho\vec{J} \]

\[ R = \rho \frac{L}{A} \quad R = \frac{V}{I} \quad \rho - \rho_0 = \rho_0\alpha(T - T_0) \]

**Question 1:** A copper wire consists of three sections with varying radii. The drift speed of the conduction electrons as a function of position along the wire is shown below. Rank the three sections, smallest to largest, on the basis of (a) current and (b) wire radius.

![Graph of drift speed vs. position](image)

**Question 2:** A copper wire has a cross sectional area of \(1.6 \times 10^{-7} \text{ m}^2\). The electron density in copper is \(8.5 \times 10^{28} \text{ 1/m}^3\). Electrons are moving through the wire with a drift velocity of 0.066 m/s. (a) What is the magnitude of the current density in the wire? [Answer: \(8.99 \times 10^8 \text{ A/m}^2\)] (b) How much current does the wire carry. [Answer: 144 A]

**Question 3:** The resistivity of silicon is 0.80 \(\Omega\cdot\text{m}\). A silicon sample forms a cylinder with a radius of 0.0063 m and a length of 0.14 m. A potential difference of 39 V is applied across its length. How much current flows through the sample? [Answer: 0.0434 A]
Question 4: A 30-W incandescent light bulb contains a tungsten filament with a circular cross section of area $1.70 \times 10^{-9} \text{ m}^2$ and length 1.05 m (it is tightly coiled to fit this length inside the bulb). The resistivity of tungsten at room temperature ($T_0 = 293 \text{ K}$) is $5.25 \times 10^{-8} \Omega \cdot \text{m}$ and the temperature coefficient of resistivity for tungsten is $4.50 \times 10^{-3} \ 1/\text{K}$. (a) What is the resistance of this light bulb at room temperature? [Answer: 32.4 Ω] (b) When a 120 V potential difference is applied to the bulb 0.25 A of current will pass through it. What is the temperature of the filament when it is plugged in? (Assume that the length and area do not change with temperature.) [Answer: 3360 K]

Question 5: Germanium has a resistivity of 0.60 Ω·m. This material forms a rectangular box that is 20 cm x 4.1 mm x 4.1 mm (20 cm long, 4.1 mm wide, and 4.1 mm high). (a) What is the resistance of this box measured across its length? [Answer: 7140 Ω] (b) Suppose that you have two identical boxes like this. You combine them along a small square face, yielding a box that is 40 cm long. What is the resistance of this box measured across its length? [Answer: 14300 Ω] (c) Instead suppose that you combine them along a large rectangular face, yielding a sample that is 20 cm long, 8.2 mm wide, and 4.1 mm high. What is the resistance of this box measured across its length? [Answer: 3570 Ω]