

Physics 712
Chapter X Problems

4. [5] The conductivity of copper is $5.96 \times 10^7 \Omega^{-1} \text{m}^{-1}$. Suppose power is being transmitted at 60 Hz along a high-voltage wire. What is the skin depth δ in copper at this frequency?

Copper is not ferromagnetic, so we assume $\mu = \mu_0$. The skin depth, relevant at low frequencies, is then given by

$$\begin{aligned}\delta &= \sqrt{\frac{2}{\mu\sigma\omega}} = \sqrt{\frac{2}{(4\pi \times 10^{-7} \text{ m} \cdot \text{kg} \cdot \text{C}^{-2})(5.96 \times 10^7 \Omega^{-1} \text{m}^{-1})(2\pi \times 60 \text{ s}^{-1})}} \\ &= \sqrt{7.083 \times 10^{-5} \frac{\text{V} \cdot \text{C}^2 \cdot \text{s}}{\text{A} \cdot \text{kg}}} = 8.42 \times 10^{-3} \sqrt{\text{J} \cdot \text{s}^2 \cdot \text{kg}^{-1}} = 8.42 \times 10^{-3} \text{ m} = 8.42 \text{ mm}.\end{aligned}$$