

25. A piece of copper wire has a resistance per unit length of $5.90 \times 10^{-3} \Omega/m$. The wire is wound into a thin, flat coil of many turns that has a radius of 0.140 m. The ends of the wire are connected to a 12.0-V battery. Find the magnetic field strength at the center of the coil.

$$B_{coil} = \frac{N\mu_0 i}{2R_{Coil}}$$

We find current by using Ohm's Law

$$i = \frac{V}{R}$$

Resistance is found from

$$R = \lambda L$$

Where λ is resistance per length, L is found from the Number of turns times circumference

$$R = \lambda L = \lambda N 2\pi R_{Coil}$$

So current is

$$i = \frac{V}{R} = \frac{V}{\lambda N 2\pi R_{Coil}}$$

So the magnetic field is

$$B_{coil} = \frac{N\mu_0 i}{2R_{Coil}} = \frac{N\mu_0}{2R_{Coil}} i = \frac{N\mu_0}{2R_{Coil}} \left(\frac{V}{\lambda N 2\pi R_{Coil}} \right) = \frac{\mu_0 V}{4\pi \lambda R_{Coil}^2}$$

$$B_{coil} = \frac{\mu_0 V}{4\pi \lambda R_{Coil}^2} = \frac{(4\pi \times 10^{-7} T m/A)(12.0 V)}{4\pi (5.90 \times 10^{-3} \Omega/m)(0.140 m)^2} = 1.038 \times 10^{-2} T$$

$B_{coil} = 1.04 \times 10^{-2} T$

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