Answer on Question #62180 - Physics – Electromagnetism

Two circular coils made of similar wire of radius 0.20m & 0.40m are connected in parallel to a battery. Calculate the ratio of magnetic field at the centre.

Solution:

Magnetic field generated by a circular coil of wire:

$$B = \frac{\mu_0 I}{2r},$$

where μ_0 is the magnetic constant, I is the electric current through a coil, r is the radius of a coil. Since the coils are connected in parallel, they have the same voltage

$$U_1 = U_2 = U.$$

Resistance of a circular wire:

$$R = \rho \frac{l}{S} = \rho \frac{2\pi r}{S},$$

where ρ is the electric resistivity of the material of a wire, S is the cross-sectional area of a wire.

Then for the first coil,

$$I_1 = \frac{U_1}{R_1} = \frac{US}{2\pi r_1 \rho}$$

$$B_1 = \frac{\mu_0 I_1}{2r_1} = \frac{\mu_0 US}{4\pi\rho r_1^2},$$

where $r_1 = 0.20m$.

For the second coil,

$$I_2 = \frac{U_2}{R_2} = \frac{US}{2\pi r_2 \rho}$$

$$B_2 = \frac{\mu_0 I_2}{2r_2} = \frac{\mu_0 US}{4\pi\rho r_2^2},$$

where $r_2 = 0.40m$.

Thus, the ratio of magnetic field at the centre:

$$\frac{B_1}{B_2} = \frac{\mu_0 US}{4\pi\rho r_1^2} \frac{4\pi\rho r_2^2}{\mu_0 US} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{0.4}{0.2}\right)^2 = 4.$$

Answer: 4.