COAXIAL SOLENOIDS

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Reference: Griffiths, David J. (2007) Introduction to Electrodynamics, 3rd Edition; Prentice Hall - Problem 5.15.

This problem is a simple extension of the result we got for the infinite solenoid. We have two coaxial solenoids along the z axis. The inner one, with radius a, has n_1 turns per unit length and carries current I clockwise when viewed down the z axis. The outer one, with radius b, has n_2 turns per unit length and carries current I counterclockwise.

To find the field everywhere, we can use the principle of superposition, together with the facts that (i) the field outside a solenoid is zero and (ii) the field inside is $B = \mu_0 nI$.

The field inside both solenoids is therefore

$$\mathbf{B}_{inner} = \mu_0 I\left(n_1 - n_2\right)\hat{\mathbf{z}} \tag{1}$$

where the direction is determined by the right-hand rule.

Between them, only the outer solenoid's field is non-zero, so we get

$$\mathbf{B}_{middle} = -\mu_0 n_2 I\hat{\mathbf{z}} \tag{2}$$

Outside both solenoids, the field is zero.