Exercise 30

Introduction to Electrodynamics

ISBN: 9780321856562

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Solution

Verified

Step 1

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The idea behind this problem is to find the energy per unit lenght and then get the inductance from the Eq. 7.30). The magnetic field inside of the wire is, using the Ampere's law:

$$2\pi sB = \mu_0 I \frac{s^2}{a^2} \implies B = \frac{\mu_0 I s}{2\pi a^2}$$

The energy per unit lenght is:

$$\begin{aligned}\mathcal{U} =& \frac{1}{2\mu_0}\int_0^a \int_0^{2\pi} \frac{\mu_0^2 I^2 s^2}{4\pi^2 a^4} s ds d\phi \\ =& \frac{1}{2}\frac{\mu_0}{8\pi} I^2\end{aligned}$$

Obviously:

$$\boxed{\mathcal{L} = \frac{L}{l} = \frac{\mu_0}{8\pi}}$$

Result

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$$\boxed{\mathcal{L} = \frac{L}{l} = \frac{\mu_0}{8\pi}}$$

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