Inductance & Magnetic Energy
Challenge Problems

Problem 1:

A very long solenoid consisting of N turns has radius R and length d ($d >> R$). Suppose the number of turns is halved keeping all the other parameters fixed. The self inductance

a) remains the same.

b) doubles.

c) is halved.

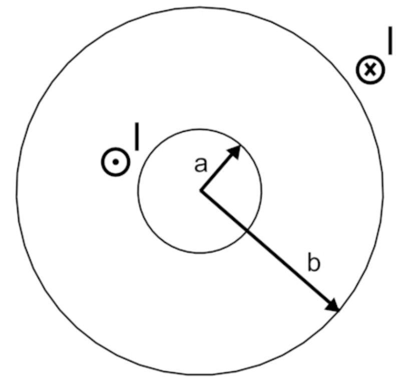
d) is four times as large.

e) is four times as small.

f) None of the above.

Problem 2:

An inductor consists of two very thin conducting cylindrical shells, one of radius *a* and one of radius *b*, both of length *h*. Assume that the inner shell carries current *I* out of the page, and that the outer shell carries current *I* into the page, distributed uniformly around the circumference in both cases. The *z*-axis is out of the page along the common axis of the cylinders and the *r*-axis is the radial cylindrical axis perpendicular to the *z*-axis.



a) Use Ampere's Law to find the magnetic field between the cylindrical shells. Indicate the direction of the magnetic field on the sketch. What is the magnetic energy density as a function of *r* for $a < r < b$?

b) Calculate the inductance of this long inductor recalling that $U_B = \frac{1}{2}LI^2$ and using your results for the magnetic energy density in (a).

c) Calculate the inductance of this long inductor by using the formula $\Phi = LI = \int_{\text{open surface}} \vec{\mathbf{B}} \cdot \mathbf{d}\vec{\mathbf{A}}$ and your results for the magnetic field in (a). To do this you must choose an appropriate open surface over which to evaluate the magnetic flux. Does your result calculated in this way agree with your result in (b)?

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