Physics 2220
Spring 2001
George A. Williams

SIXTH MIDTERM

4

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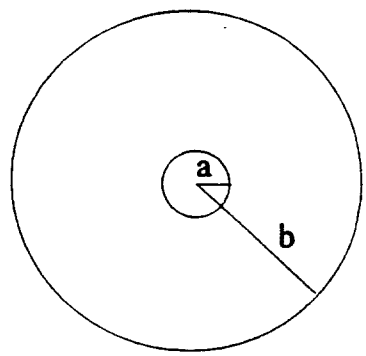
SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

A coaxial cable consists of an inner conductor of outer radius a, and a thin outer conductor of inner radius b. A current I_o (I_o = 3.22 A) flows on the inner conductor and back on the outer conductor.



a = 0.100 cm
b = 0.500 cm

15 (a) Calculate the energy stored in the magnetic field between the conductors for a length ℓ = 2.25 m of this cable.

10 (b) Using the result above, calculate the inductance of 3.75 m of this cable.

(a) $a \le r \le b$

$$\oint B \cdot d\ell = \mu I_{enclosed} = \mu I_o$$

$$B = \frac{\mu I_o}{2\pi r} \qquad \text{energy density } \rho = \frac{B^2}{2\mu} = \frac{\mu I_o^2}{8\pi^2 r^2}$$

$$E = \int \rho dV = \ell \int_a^b \left(\frac{\mu I_o^2}{8\pi^2 r^2}\right) 2\pi r dr = \frac{\mu I_o^2 \ell}{4\pi} \ln\frac{b}{a}$$

$$= \frac{4\pi\times10^{-7}\times(3.22)^2\times 2.25}{4\pi} \ln\frac{0.500}{0.100} = 3.75\times10^{-6}\,(J)$$

(b) $$E = \frac{\mu I_o^2 \ell}{4\pi}\ln\frac{b}{a} = \frac{1}{2} L I_o^2$$

$$L = \frac{\mu \ell}{2\pi}\ln\frac{b}{a} = \frac{4\pi\times10^{-7}\times 3.75}{2\pi}\ln 5 = 1.21\times10^{-6}\,(H)$$

(a) $$\Phi = \int B\cdot dA = \int_a^b \frac{\mu I_o}{2\pi r}\ell\, dr = \frac{\mu_o I \ell}{2\pi}\ln\frac{b}{a}$$

$$\because E = \frac{1}{2}\Phi I = \frac{\mu_o I \ell}{4\pi}\ln\frac{b}{a} = 3.75\times10^{-6}\,J$$

(b) $$L = \frac{\Phi}{I} = \frac{\mu_o \ell}{2\pi}\ln\frac{b}{a}$$