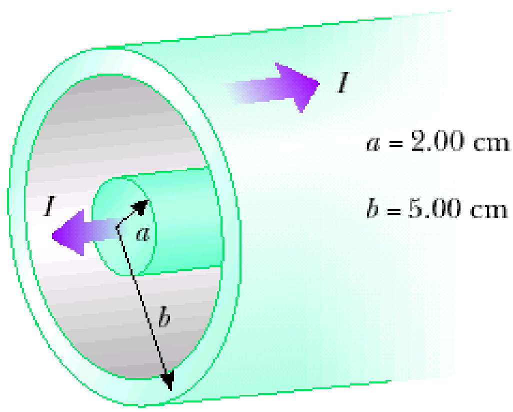
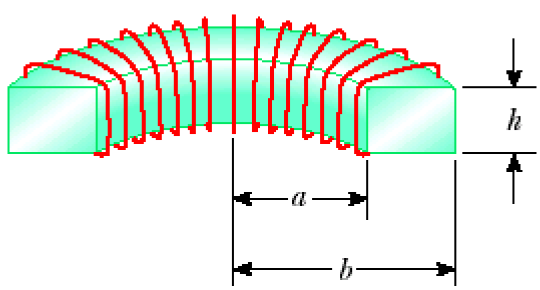
# Physics 2201 E&M
# Homework #17 – Due Mar. 15, 2016 by 3pm
# (hand in to drop box outside 3L24)

1. *Superconducting power transmission.* The use of superconductors has been proposed for power transmission lines. A single coaxial cable (see figure below) could carry $1.25 \times 10^3$ MW (the output of a large power plant) at 150 kV, DC, over a distance of 1 000 km without loss. An inner wire of radius 2.00 cm, made from the superconductor $Nb_3Sn$, carries the current $I$ in one direction. A surrounding superconducting cylinder, of radius 5.00 cm, would carry the return current $I$. In such a system, what is the magnetic field (a) at the surface of the inner conductor and (b) at the inner surface of the outer conductor? (c) How much energy would be stored in the space between the conductors in a 1000-km superconducting line? (d) What is the pressure exerted on the outer conductor?

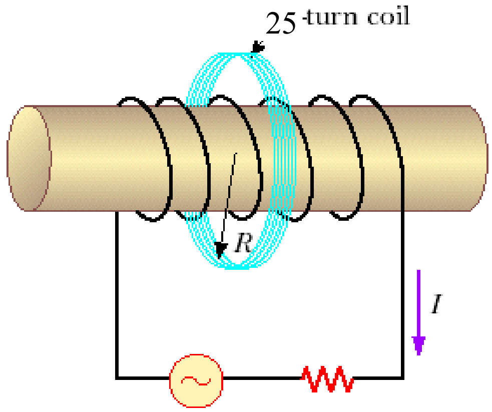



2. The toroid in the figure below consists of $N$ turns and has a rectangular cross section. Its inner and outer radii are $a$ and $b$, respectively. Show that the inductance of the toroid is

$$L = \frac{\mu_0 N^2 h}{2\pi} \ln \frac{b}{a}$$

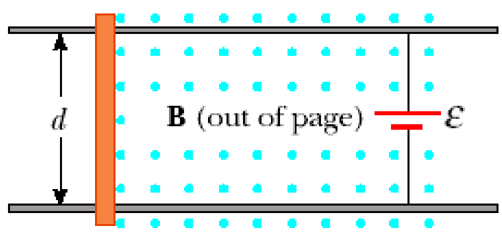


3. A coil of 25 turns and radius 4.0 cm surrounds a long solenoid of radius 2.50 cm and 250 turns/meter (see figure below). The current in the solenoid changes as $I = (16.00\text{ A})\sin(720t)$. Find the induced emf in the 25-turn coil as a function of time.

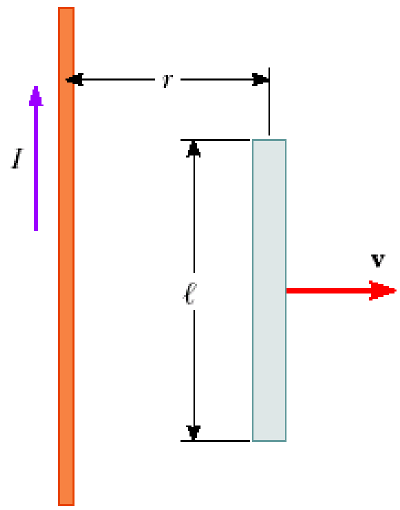



4. A bar of mass $m$, length $d$, and resistance $R$ slides without friction in a horizontal plane, moving on parallel rails as shown in the figure below. A battery that maintains a constant emf $\mathcal{E}$ is connected between the rails, and a constant magnetic field **B** is directed perpendicularly to the plane of the page. Assuming the bar starts from rest, show that at time $t$ it moves with a speed

$$v = \frac{\mathcal{E}}{Bd}\left(1 - e^{-B^2 d^2 t/mR}\right)$$




5. A conducting rod moves with a constant velocity v in a direction perpendicular to a long, straight wire carrying a current $I$ as shown in Figure below. Show that the magnitude of the emf generated between the ends of the rod is $|\mathcal{E}| = \dfrac{\mu_0 v I \ell}{2\pi r}$.



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