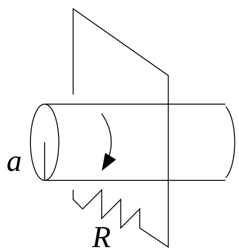
Physics 333 **Electromagnetic Theory I** **Fall 2006**

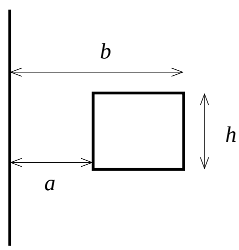
Review Questions for Chapter 7

1. A wire loop encloses a solenoid, as shown. The solenoid carries a varying current $I(t) = I_0 \cos(\omega t)$. Determine the current in the outer loop.



Answer: $I_{outer} = \dfrac{\mu_0 n I_0 \omega \pi a^2}{R} \sin(\omega t)$

2. Consider two "loops": one is a straight line wire (that loops back around to itself somewhere infinitely far away) and the other is a rectangular loop. The loops lie in the same plane. Determine the mutual inductance M.

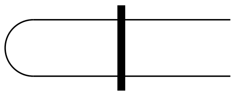


Answer: $M = \dfrac{\mu_0 h}{2\pi} \ln\left(\dfrac{b}{a}\right)$

3. Show that Ampere's Law is inconsistent with charge conservation.

Answer: Take divergence: $\nabla \cdot (\nabla \times \mathbf{B}) = \mu_0 \nabla \cdot \mathbf{J}$. The left side is zero for any vector field $\mathbf{B}$. The right side should equal $-\mu_0(\partial\rho/\partial t)$ by the continuity equation, so these are inconsistent.

4. A magnetic rail gun is a U-shaped loop of wire, with a sliding bar across it that completes a circuit. The goal is to get the bar accelerating to the right. Find two different ways to make this happen (using **B** fields and currents).



Answer: (a) standard method: put a battery in the loop so that current flows clockwise, and place loop in a magnetic field pointing into page. (b) alternate method: no battery, just start with a large **B** field pointing into the page, and then reduce its strength. This will accelerate the loop to the right until $\mathbf{B} = 0$. (What happens next?).