PHYS 4330 ELECTRICITY & MAGNETISM II

HOMEWORK ASSIGNMENT 04

DUE DATE: February 25, 2020

Instructor: Dr. Daniel Erenso Name: ______________________________

Mandatory problems: *Problems 1 & 3*

Student signature:_______________________________________

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1. In homework Assignment one, Problem 1, we have considered a copper rod of length, h, mass, m, and electric resistance, R, sliding with negligible friction on metal rails that have negligible electric resistance (see Fig. 1). The rails are connected on the right with a wire of negligible electric resistance, and a magnetic compass is placed under this wire. There is a uniform magnetic field, $\vec{B}$, pointing out of the page that fills the entire region.In this problem we found the current generated to be

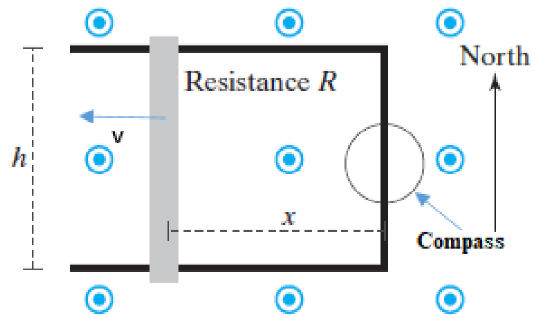

Figure 1: A rod sliding on u-shaped wire in a uniform magnetic field.

$$I_{in} = \frac{vBh}{R}. \tag{1}$$

Suppose the copper rod and the rails are made of a superconductor where the resistance is zero (R =0). In this case the the current is limited only by the back emf associated with the self inductance, L, of the loop

$$V_{back\ emf} = -L\frac{dI}{dt}, \tag{2}$$

which ordinarily be negligible in comparison with the induced voltage

$$V_{in} = I_{in}R. \tag{3}$$

Show that in this regime the rod with mass, m, executes simple harmonic motion with a frequency

$$\omega = \frac{Bh}{\sqrt{mL}}. \tag{4}$$

How would the compass respond in this case?

2. A thin conducting cylindrical shell of radius b contains a coaxial wire of radius a and magnetic permeability μ_0. The space between the wire and the shell is filled with material of permeability μ. Find the self -inductance per unit length of the line.

3. A power transmission line is constructed from two thin copper plate of width,w, separated by a very small distance,h, as shown in Fig. 2 where $h << w$ The current, I, travels down one strip and back along the other. In each case, the current spreads out uniformly over the surface of the plate.

(a) Find the capacitance per unit length, C/l.

(b) Find the inductance per unit length, L/l.

(c) What is the product,CL/l^2, numerically?

(d) C/l and L/l will, of course, vary from one kind to transmission line to another, but the product is a universal constant. Find C/l and L/l for Example 7.17 (in my note) assuming the space between the cylinders is vacuum with electrical permittivity, ϵ_0, and magnetic permeability, μ_0, and show that the product is indeed a universal constant.

(e) If the strips are insulated from one another by a nonconducting material of permittivity, ϵ, and permeability, μ, what is then the product, CL/l^2.

4. Griffiths Problem 7.53

5. Griffiths Problem 7.56

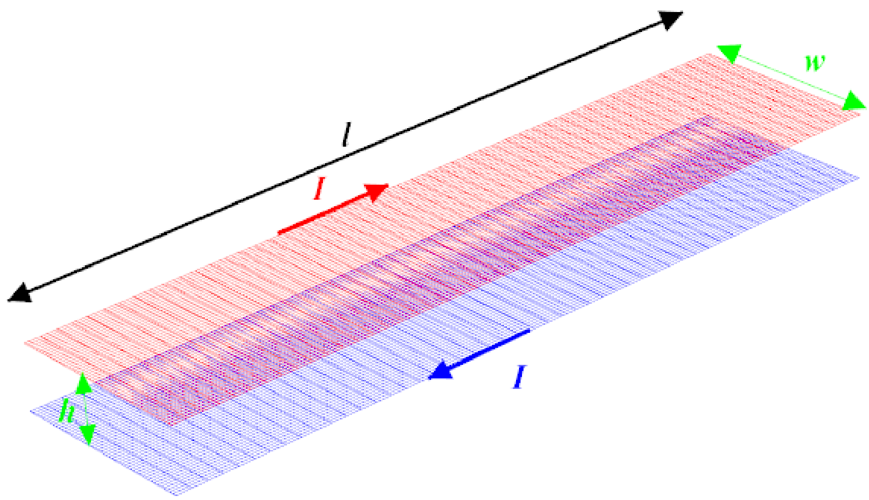

Figure 2: Power transmission line.