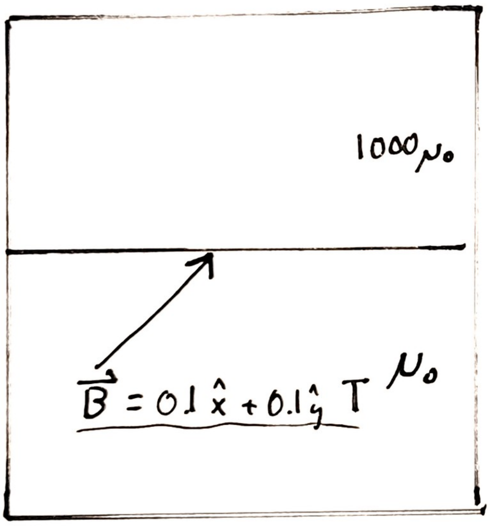
Exam 3 Practice

(no due date; just for practice)

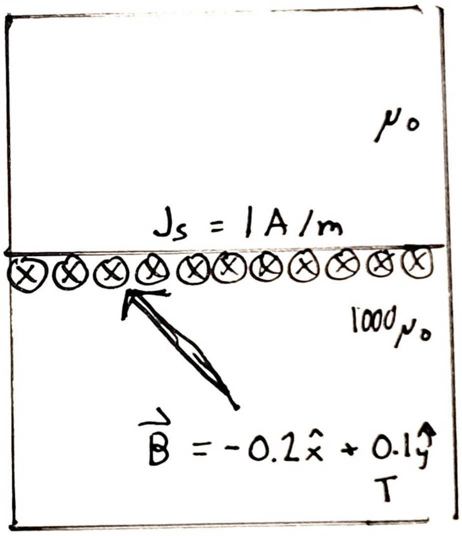
1. Boundary Conditions

For each of the problems below, you are shown a boundary between two materials and given a magnetic field vector in the lower material. Calculate what the corresponding electric or magnetic field would be in the upper material.

a.)



b.)



2. Conductor Fields

A 1000m copper conductor has a round cross section with radius 1cm. A DC voltage of 100mV is applied at one end and it is grounded at the other end. The conductivity of copper is 5.9*10^7 S/m.

a.) What is the current density assuming that the current is uniformly spread out?

b.) Calculate the magnetic field B both inside and outside the wire. (The permeability of copper is essentially the same as the permeability of free space).

c.) Calculate the magnetic vector potential outside the wire.

d.) What is the relationship between flux and flux linkage for this wire?

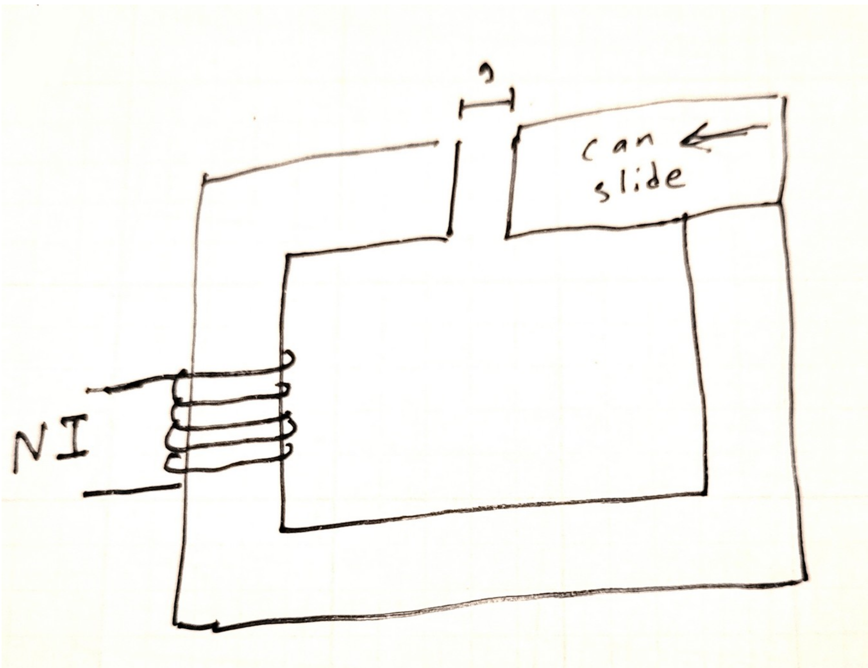
e.) Calculate the internal inductance of the wire. (This is the inductance due to the magnetic fields inside the wire; it ignores the fields outside.)

f.) Describe the region over which you must integrate in order to calculate the total flux that contributes to the external inductance. (This is the flux outside the wire).

h.) Calculate the magnetic energy density as a function of radius r inside the wire.

3. Magnetic Circuit

Consider the magnetic circuit pictured below. The gap is 5cm wide and has a 10cm x 10cm cross sectional area. The rest of the circuit has the same cross-sectional area and the perimeter of the circuit is 1m. Assume that the permeability of the metal that makes of this loop is 2500 times as high as free space. Neglect any effects due to the slight variation between the loop's inner and outer circumference. Assume the energizing coil contains 1A of current and 1000 turns.



a.) Calculate the following quantities as a function of air gap length g:

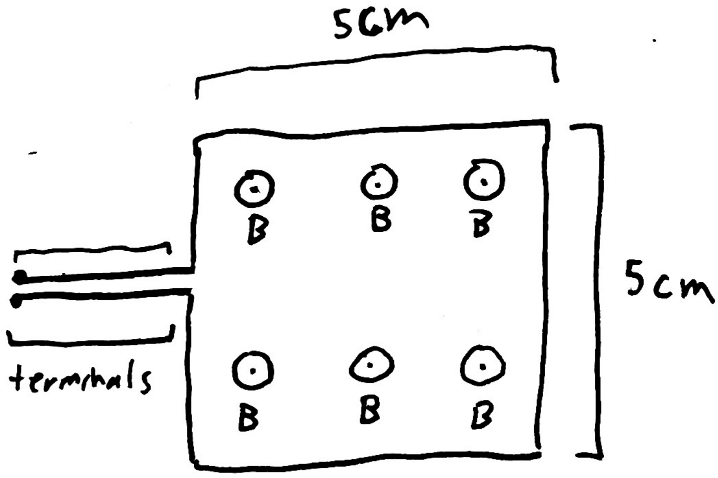
i) Total magnetic circuit reluctance

ii.) Magnetic flux

iii) Inductance

b.) Calculate the magnetic energy density on either side of the gap, the resulting magnetic pressure, and the force on the sliding piece.

4.) Faraday's Law / Current and Force



A square loop (pictured above) is placed in a uniform B-field pointing up in the z direction. The loop is 5cm on each side. Neglect the presence of the terminals when considering the loop's geometry – simply treat the loop as a square.

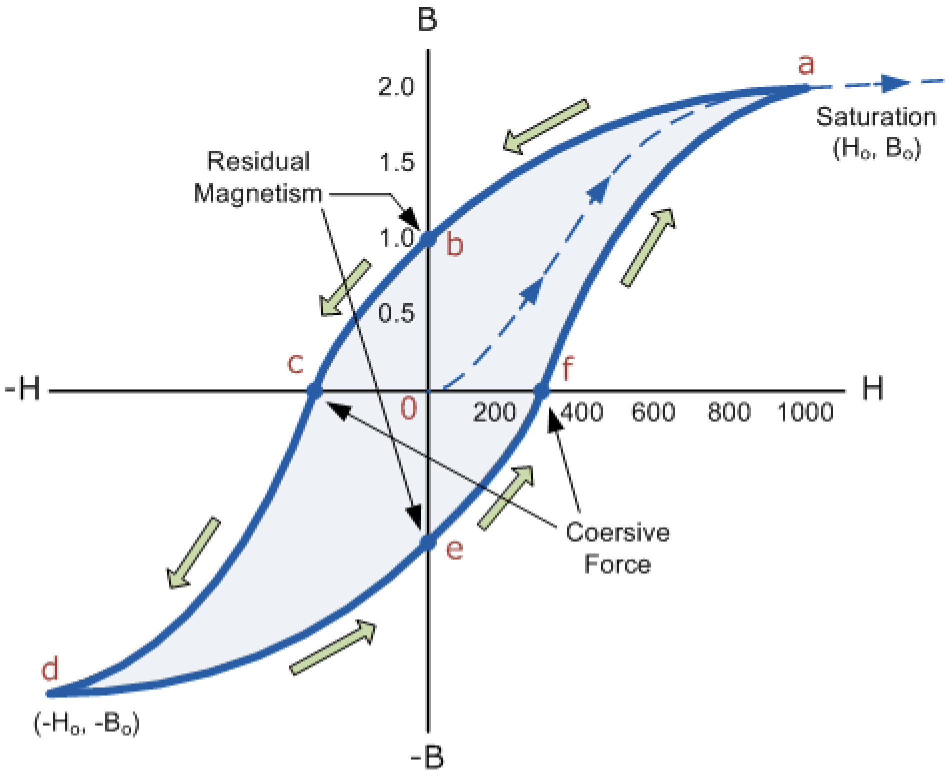
a.) Suppose that the amplitude of the magnetic field is defined as follows (in units of teslas):

$$\vec{B} = 0.1sin(200\pi t)\hat{z}$$

Write the expression for the emf that will appear at the terminals. How would your answer change if the loop had 5 turns instead of just one turn?

b.) Now suppose that the magnetic field is a constant 0.1 T pointing up (doesn't change with time), and we put a constant 100mA current clockwise through the loop. Calculate the magnitude and direction of the force on each side of the loop and provide a sketch. If the loop is freely permitted to move under the influence of this force, will it move or rotate?

5.) Magnetization Curve



Above, a magnetization curve is shown. The initial behavior of the material as it is magnetized from a non-magnetized state is shown by the dotted line.

a.) When the external magnetic field is initially applied, the total field B can be related to the applied H via the permeability μ which can be treated as constant at lower magnitudes of H. How can this permeability μ be determined from the graph above?

b.) As the H field becomes very strong, what does μ approach and why?

c.) Explain the difference between hard and soft magnetic materials and the advantages of each one.