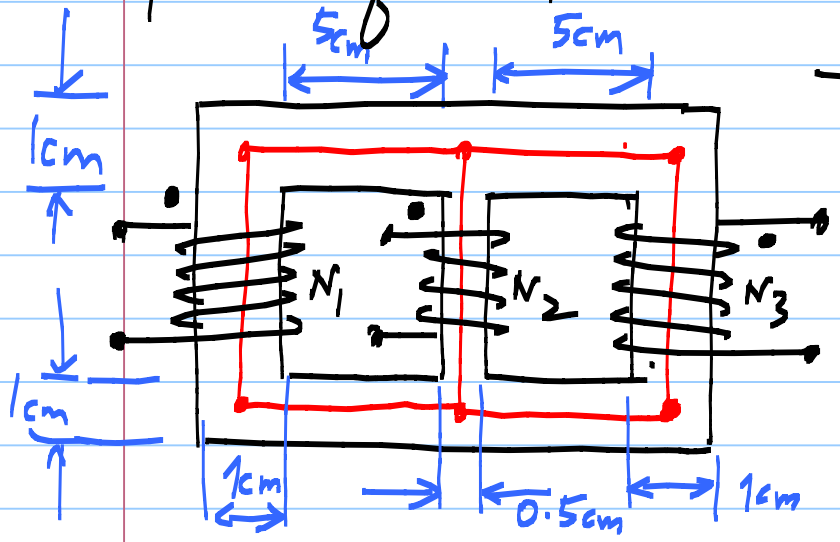
EC1010: Electrical and Magnetic circuits

Note Title 4/10/2012

Problem set 6:

1. Calculate the self inductance of each coil and the mutual inductance (including the sign) between each pair of coils. The material has $\mu_r = 1000$ and has a thickness of 1cm everywhere.

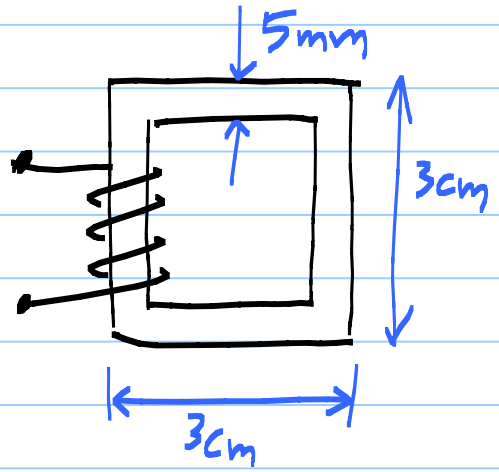


For segment lengths, use the length along the center line (shown in red)

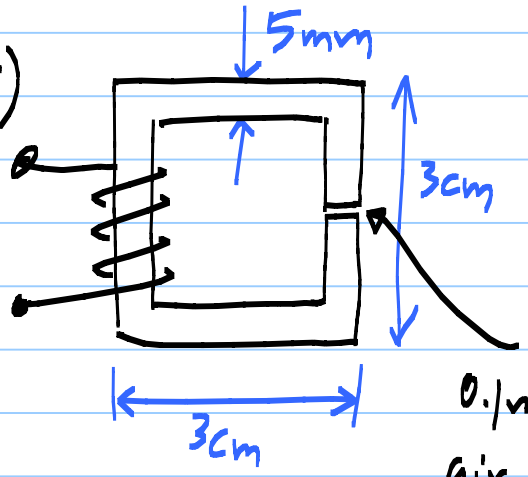
$N_1 = 100$ turns, $N_2 = 50$ turns, $N_3 = 200$ turns

2. You are required to design a 5π mH inductor with a core which has a 5mm x 5mm square cross section. Calculate the number of turns required in the following 3 cases. $\mu_r = 1000$; segment lengths are along the center line.

(i)



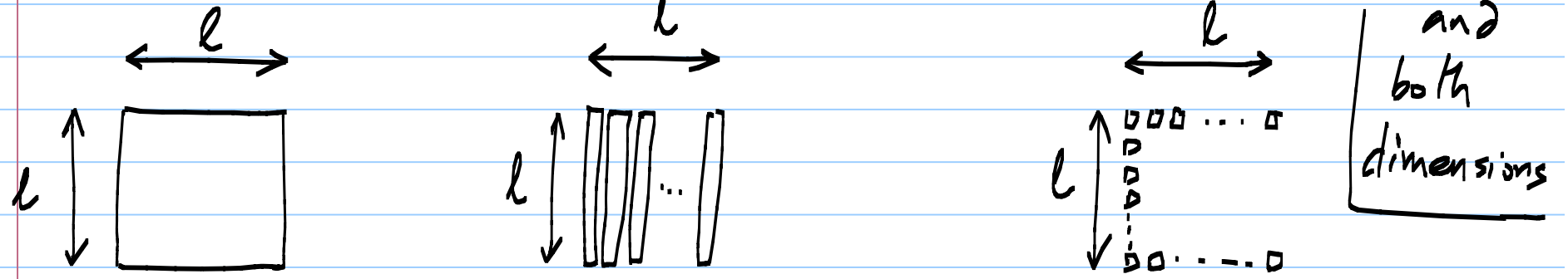
(ii)



(iii) Single layer air core solenoid. (assume 0.2mm wire thickness)

3. What is the point of having an air gap as in (ii) above? (Hint: Calculate $|\vec{B}|$ in the core for a given current in (i) & (ii) and consider all the "features" of a ferromagnetic material)

4. Eddy current calculations: Assume that there is a flux density $B_p \sin \omega t$ perpendicular to the loop surfaces. Denote the resistance of the single loop by R. Comment on the loss reduction due to lamination in one and both dimensions

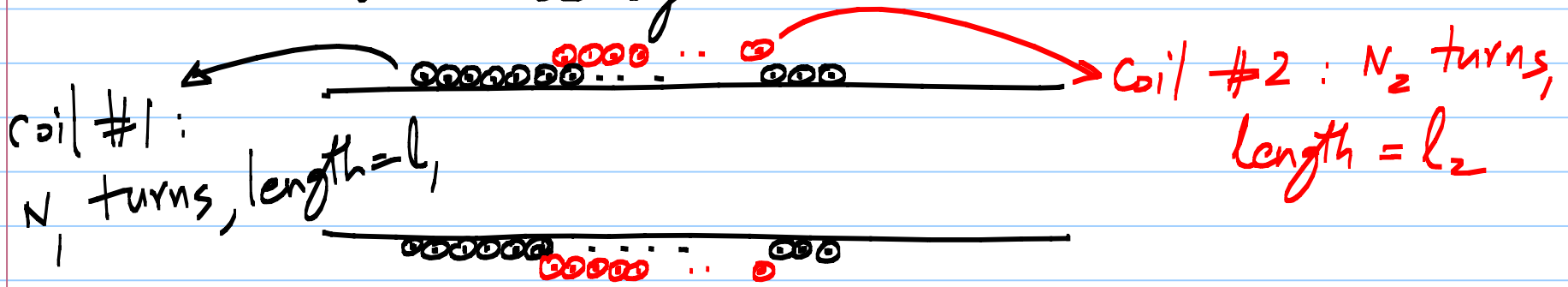


(i) Single loop.

(ii) Sliced in x direction in N_1 loops ($N_1 \gg 1$)

(iii) Sliced in x direction in N_1 pieces & in y direction in N_2 loops ($N_1, N_2 \gg 1$)

5. An air-core mutual inductor is made by winding one solenoid on top of another (assume both have the same cross sectional area). Calculate the mutual inductance by



(i) Passing a current i_1 through coil #1 and finding the voltage induced in coil #2

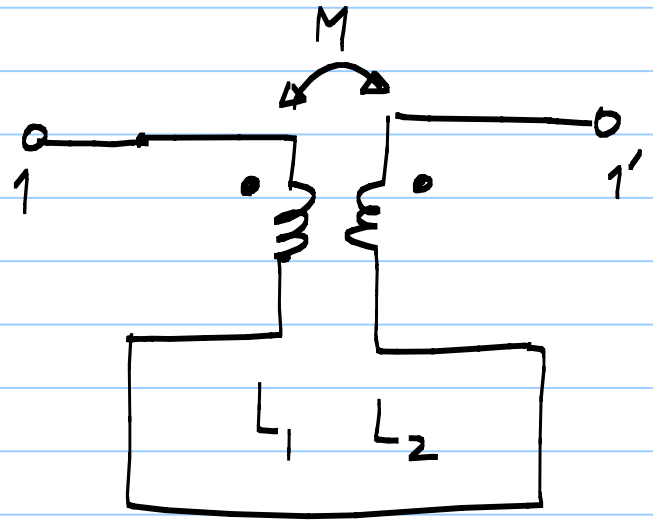
(ii) Passing a current i_2 through coil #2 and finding the voltage induced in coil #1

[Note: both (i) & (ii) should yield the same mutual inductance. If not see where you have gone wrong & reconcile. All the usual solenoid assumptions apply]

(iii) Calculate the coupling coefficient k. When is this maximum? What is the maximum value?

6. Calculate the single port equivalent of the following between the terminals 1-1'

(i)



(ii)