NTNU

TFE4120 Electromagnetics - Crash course

Exercise 5

Problem 1

Given a tightly wound toroid with radius a, and N number of turns that is conducting a constant direct current I. Use $a = 10\text{cm}$, $N = 1000$ and $I = 1\text{mA}$. Find the magnetic field **B** everywhere (both inside and outside the toriod) assuming the core consists of

a) vacuum.

b) an iron core with $\mu_r = 5000$.

Problem 2

a) Find the self inductance L of a long, tightly wound solenoid.

b) If the number of turns is doubled (and everything else remains the same), what will happen with the self inductance?

c) Assume that the current is decaying from I_0 to 0 during the time T. Find the induced voltage as a function of I_0, T and L. Use this to explain why there is a spark when we unplug a vacuum cleaner.

Problem 3

A telephone line and a power line is running parallel with each other. Both the power line and the telephone line consists of two thin, parallel conductors as shown in the figure below. The power line is assumed to be infinitely long, and the telephone line is assumed to be a closed, rectangular loop with length l and width b. Assume that the thickness of the conductor is negligible compared to the distances a, b, d, and l.

a) Find the mutual inductance between the to lines.

Hint: Use $L_{12} = \Phi_{12}/I_1$.

Power line   Telephone line
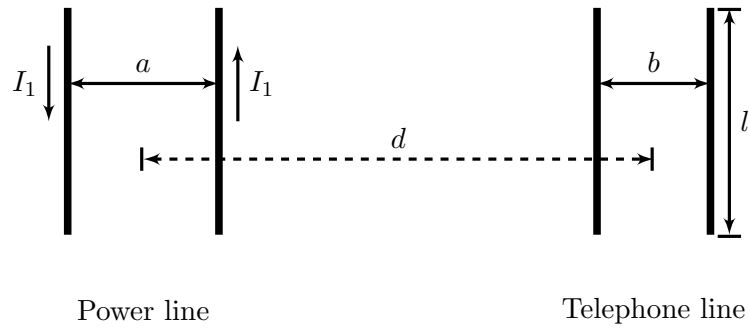
b) Find the amplitude of the induced electromotive force in the telephone line when there is a harmonic alternating current with an amplitude I_0 and a frequency f in the power line. As a numerical example, we say that $f = 50\text{Hz}$, $I_0 = 100\text{A}$, $l = 500\text{m}$, $d = 10\text{m}$, $a = 50\text{cm}$, and $b = 10\text{cm}$.

(Answer: 1.57mV.)

c) Why is it a good idea to twirl the conductors of the telephone line?