ENEL 476 – Winter 2014

Assignment #1 Time varying fields (Chapter 9)

Due on Friday January 31 at 4 pm in the drop box on 2nd floor of ICT

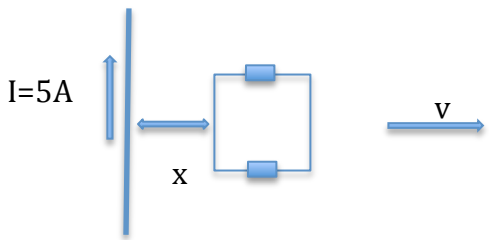
1. An antenna radiates signals into free space. Assume that $\varepsilon=\varepsilon_o$, $\mu=\mu_o$, $\sigma=0$ and $\mathbf{J}=0$. The magnetic field at a distance from the antenna is described as:

$$\mathbf{H}(x,t)=10\cos(1.02x10^8t-\beta x)\mathbf{a}_y \text{ A/m}$$

   a) Express the magnetic field in phasor form ($\mathbf{H}_s(x)$).
   b) Find the associated electric field in phasor form ($\mathbf{E}_s(x)$).
   c) Find β.
   d) Express the electric field in the time domain ($\mathbf{E}(x,t)$)
   e) Find the displacement current density, $\mathbf{J}_D$.

2. Consider two wire loops placed in the same plane such that their centres are at the same location (see Figure). The length of one side of the square loop is 1 m, and the circular loop has radius of 1 cm. A current of I=10 sin ωt A flows through the outer loop in the counter clockwise direction. The inner loop has resistance of R=10 Ω. Find an expression for the induced current in the circular loop.

3. A loop is moving away from an infinitely long wire in which a current of I=5 A is flowing. The square loop contains two resistors of R=5 Ω and has side length of 10 cm. If the velocity of the loop is $\mathbf{v}=2.5\,\mathbf{a}_x$, find the voltage drop across the resistors. Assume that the wire is located at the origin and express the voltage drop as a function of the separation between the wire and loop (x). Indicate the direction of current flow in the loop, as well as the polarity of the voltage drop across each resistor.



4. The magnetic field is given by:

$$\mathbf{H}(x,t)=8\cos(2x10^{6}t-0.02x)\mathbf{a}_y \text{ A/m}$$

If $\varepsilon_r=1$, $\sigma=0$ and $\mathbf{J}=0$, find an expression for the electric field, $\mathbf{E}(x,t)$ and the magnetic permeability, μ_r.

5. An interface is formed between a perfect conductor and a material with $\mu_r=5$, $\varepsilon_r=10$ and $\sigma=0$. The electric field on the surface of the conductor at point P(-1,-2,3) is:

$$\mathbf{E}=(25\mathbf{a}_x-15\mathbf{a}_y+30\mathbf{a}_z)\cos 10^{6}t \text{ V/m.}$$

a) Find a unit vector normal to the surface of the conductor if the origin of the co-ordinate system is located in the conductor.
b) Find the surface charge density (ρ_s) at point P.