COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering
Lecturer: Associate Prof. Dr. Hussein Hamed Mahmoud Ghouz
Course: Electromagnetics (EM_I)
Course Code: EC341 **Time : 120 Min**
Date : Sat. 10, Jan., 2015 **Total Marks : 40**

Anwser All Questions (Fall 2014/2015)

Question No.1 (8-Mark):

(a)State Gauss's law of electrostatic field, and then verify it for a point charge located in free-space **(2-Mark)**

(b)State and prove ampere's law of magnetostatic field, and then verify it for an infinite conducting wire carrying a stationary current. **(2-Mark)**

(c)Consider two parallel long wires having equally radii (**$r_1=r_2=b=5.0$mm**) and separated by a distance **R=1.0m**. The current in each wire has constant and equal value (**$I_1=I_2=30$mA**) and opposite in direction. Find the following**:** **(4-Mark)**

1. Capacitance and mutual inductance
2. Electric and magnetic forces
3. Electric and magnetic fields at any point between the wires

Question No.2 (8-Mark):

(a) Consider a small circular loop of radius **b=0.25m** carrying a stationary current **I_1=30** mA as shown in the Fig.1 (a). Find the magnetic field intensity at the point **P (0, 0, z)** **(3-Mark)**

(b)State Biot-Sevart' law of magnetostatic field for a finite conducting line **(2-Mark)**

(c) A group of conducting lines forms two closed loops, upper and lower (square loop plus half circular loop), carrying constant currents as shown in Fig.1 (b), assume: **$I_2=I_3=30$ mA, d=0.8m, and b=d/4**, find the magnetic field at the point **P** **(3-Mark)**

Fig.1 (a)

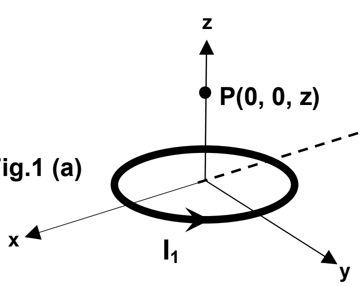
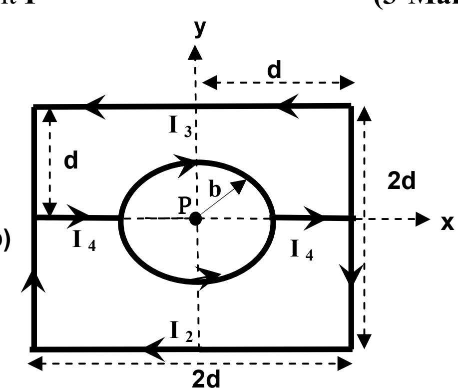


Fig.1 (b)



Question No.3 (12-Mark)

(a)Derive the equations of the boundary conditions between two dielectric materials. **(2-Mark)**

(b) Two lossy materials (**$\varepsilon_1=4.4\varepsilon_o$, $\sigma_{d1}=3\times10^{-3}$ & $\mu_1=\mu_o$**, and **$\varepsilon_2=2.2\varepsilon_o$, $\sigma_{d2}=5.0\times10^{-3}$ & $\mu_2=\mu_o$**) are used to fill the space between the inner and outer conductors of a coaxial cable as shown in **Fig.2**. The inner conductor is kept with a positive voltage **V_o=5.0** volt and the outer conductor is grounded (zero voltage). Assume, the radius of inner conductor and thickness of the outer conductor can be neglected, find the following**:**

1. The capacitance **C** and the inductance **L** per unit length **(2-Mark)**
2. The conductance **G=1/R** per unit length **(2-Mark)**
3. Draw the equivalent circuit **(2-Mark)**

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(c) Given two isolated and infinite conducting planes form a sector of a convex angle as shown in **Fig.3**. One of the conducting planes is kept at constant potential $\mathbf{V_o}$ while the other is grounded. Solve the Laplace equation to find the potential and the electric field distributions between the conducting planes. **(4-Mark)**

Question No.4 (12-Mark)

(a) Given a corner shape of infinite copper conducting planes having a zero potential and an angle $\boldsymbol{\alpha}$ of 90^o as shown in **Fig.4**. Assume a point charge Q=50 nC is located at a point between the two conductors. Assume d=0.8m, use the image method to find the following**:** **(5-Mark)**

1. The electric potential and electric field at the observation point P(x, 0, z)

2. The electric force between ground planes and the point charge Q

(b) Prove that the Maxwell's curl equations in case of Time-Varying fields are given by: **(4-Mark)**

$$\nabla \times \overline{\mathbf{E}} = -\frac{\partial \overline{\mathbf{B}}}{\partial \mathbf{t}} \quad \text{and} \quad \nabla \times \overline{\mathbf{H}} = \overline{\mathbf{J}} + \frac{\partial \overline{\mathbf{D}}}{\partial \mathbf{t}}$$

(c) A Time-Harmonic electric field of a plane wave having a single component (**x-component**) propagates in a lossless dielectric medium ($\varepsilon=\varepsilon_o\varepsilon_r$ & $\mu=\mu_o$) along the **z-direction**. The electric field intensity has a complex instantaneous form given by:

$\mathbf{E}$ (t, z) = 10^{+03} $\mathbf{exp\{j\,(2\pi \times 10^9\, t - \frac{3\pi}{4} z + \frac{2\pi}{3})\}\, a_x}$. Find ε_r and $\mathbf{B}$ (t, z) **(3-Mark)**

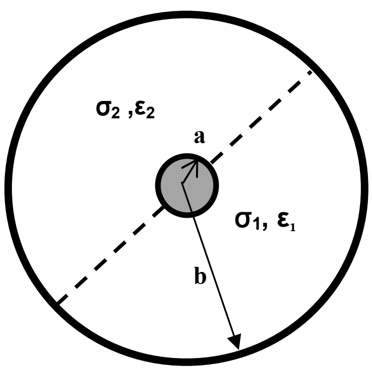

Fig.2

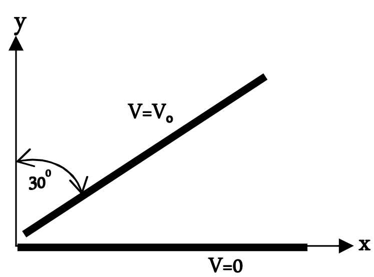

Fig.3

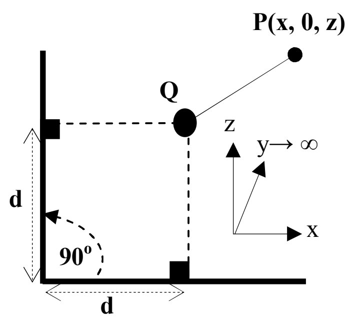

Fig.4

Constants and Formulas

$1/(4\pi\varepsilon_o) = 9\text{x}10^9$ m/F $\qquad \varepsilon_o=10^{-09}/(36\text{x}\pi)$ F/m $\qquad \mu_o=4\pi\text{x}10^{-07}$ H/m

$$\nabla V = \frac{\partial V}{h_1 \partial u_1}\mathbf{a}_{u1} + \frac{\partial V}{h_2 \partial u_2}\mathbf{a}_{u2} + \frac{\partial V}{h_3 \partial u_3}\mathbf{a}_{u3}$$

$$\nabla^2 \mathbf{V} = \frac{1}{h_1 h_2 h_3}\left(\frac{\partial}{\partial u1}\left(h_2 h_3\left(\frac{1}{h_1}\frac{\partial V}{\partial u_1}\right)\right) + \frac{\partial}{\partial u2}\left(h_1 h_3\left(\frac{1}{h_2}\frac{\partial V}{\partial u_2}\right)\right) + \frac{\partial}{\partial u3}\left(h_1 h_2\left(\frac{1}{h_3}\frac{\partial V}{\partial u_3}\right)\right)\right)$$

$$\nabla \text{X}\ \overline{\mathbf{A}} = \frac{1}{h_1 h_2 h_3}\begin{vmatrix} h_1 \mathbf{a}_{u1} & h_2 \mathbf{a}_{u2} & h_3 \mathbf{a}_{u3} \\ \frac{\partial}{\partial u1} & \frac{\partial}{\partial u2} & \frac{\partial}{\partial u3} \\ h_1 A_{u1} & h_2 A_{u2} & h_3 A_{u3} \end{vmatrix}$$

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