MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY, ALLAHABAD

Electronics and Communication Engineering Department

B. Tech 2nd Year (Semester-IV)

End Semester Examination 2016-17

Electromagnetic Theory (EC-1403)

(Only for Electrical Engineering students)

M.M: 60 Time: 3.00 Hours

Note: Attempt all questions. Symbols and notations carry their usual meaning.

1. a) Given $\varphi = xy + yz + zx$, find the directional derivative of φ at (1, 2, 3) in the direction towards point (3, 4, 4). 2

   b) Show that $\vec{B} = (y + z\cos xz)\,\hat{a}_x + x\,\hat{a}_y + x\cos xz\,\hat{a}_z$ is conservative. 2

   c) Calculate the total outward flux of vector $\vec{F} = \rho^2 \sin\varphi\,\hat{a}_\rho + z\cos\varphi\,\hat{a}_\varphi + \rho z\,\hat{a}_z$ through the hollow cylinder defined by $2 \le \rho \le 3, 0 \le z \le 5$. 2

2. A charge distribution with spherical symmetry has density $\rho_v = \begin{cases} \rho_o & 0 \le r \le R \\ 0 & r > R \end{cases}$ 6

   Determine V everywhere and the energy stored in region r < R.

3. Two parallel sheets of glass ($\varepsilon_r = 8.5$) mounted vertically are separated by a uniform air gap between their inner surface. The sheets, properly sealed, are immersed in oil ($\varepsilon_r = 3$) as shown in Figure 1. A uniform electric field of strength 2 kV/m in the horizontal direction exists in the oil. Calculate the magnitude and direction of the electric field in the glass and the enclosed air gap when (a) the field is normal to the glass surfaces and (b) the field in the oil makes an angle of 75° with a normal to the glass surfaces. 6

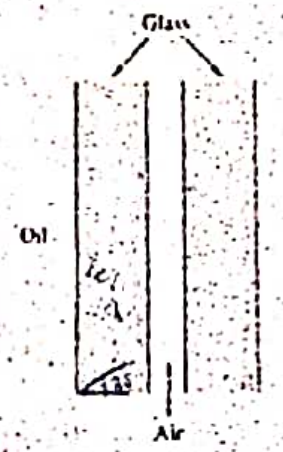

Figure 1

4. a) In a one dimensional device, the charge density is given by $\rho_v = \rho_o\, x/a$. If $\vec{E} = 0$ at x = 0 and V = 0 at x = a, find V and $\vec{E}$. 3

   b) Derive the expression of capacitance for a coaxial capacitor. 3

5. a) A circular loop located on $x^2 + y^2 = 9$, z = 0; carries a direct current of 10A along $\hat{a}_\varphi$. Determine $\vec{H}$ at (0, 0, 4) and (0, 0, -4). 3

   b) Planes z = 0 and z = 4 carry current $\vec{K} = -10\,\hat{a}_x\ A/m$ and $\vec{K} = 10\,\hat{a}_x\ A/m$, respectively. Determine $\vec{H}$ at (1, 1, 1) and (0, -3, 10). 3

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6. a) Derive the law of refraction of magnetic fields if the boundary is not current free. 2

b) The xy plane serves as the interface between two different media. Medium 1 ($z < 0$) is filled with a material whose $\mu_r = 6$, and medium 2 ($z > 0$) is filled with a material whose $\mu_r = 4$. If the interface carries current $(1/\mu_o)\ \vec{a}_y$ mA/m, and $\vec{H}_2 = 5\ \vec{a}_x + 8\ \vec{a}_z$ mW/m², find $\vec{H}_1$ and $\vec{B}_1$. 4

7. Derive all Maxwell's equations for time varying fields. 6

8. In a medium characterized by $\sigma = 0, \mu_r = \mu_o, \varepsilon_r = \varepsilon_o$ and $\vec{E} = 20 \sin(10^8 - \beta z)\ \vec{a}_y$ V/m, calculate β and $\vec{H}$. 6

9. Find out the expression for *propagation constant, intrinsic impedance, attenuation constant* and *loss tangent* for a wave propagating in a lossy dielectric. 6

10. Derive the expression for *propagation constant* and *characteristic impedance* of a transmission line using L-model. 6