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PES

PES Institute of Technology, Bangalore

(Autonomous Institute under VTU, Belgaum)

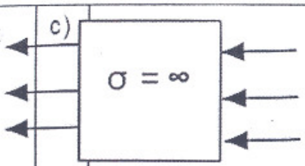
12EC205

SEE B. E. 3rd SEMESTER – December 2013

End Semester Examination

12EC 205 / TE 206(for EC) - Electromagnetic Field Theory

Time: 3 Hours		Answer All Questions	Max Marks: 100
1.	a)	Consider a long line carrying a uniform electric charge of ρ_L Coulomb per unit length. Let this line be along the 'z' axis. Consider a planar 'window' at $y = 1$, stretching from $z = 1$ to 2, and $x = 2$ to 3. Find the total electric flux passing through this window.	[8]
	b)	Four point charges of 1 nC each are located at the vertices of a square on the x-y plane at : (1,1,0), (-1,1,0), (-1,-1,0), (1,-1,0). (i) Derive the expression for the electric scalar potential at any point (x,y,z). (ii) Use the result of (i) to find the electric field at any point (x,y,z).	[2+4]
	c)	A uniform volume charge density of 1 nC/m³ is confined within a spherical volume of radius 'a'. (i) From considerations of symmetry, what will be the direction of the electric field? (ii) Apply Gauss' law to determine the electric field in the region $r < a$ (iii) Apply Gauss' law to determine the electric field in the region $r > a$	[1+3+2]
2.	a)	Consider two concentric cylinders of radiuses 'a' and 'b' ($a>b$) . The space between these two cylinders is filled with a material of dielectric constant ε and conductivity σ . The inner cylinder is subject to a potential of Vo Volts. The outer cylinder is subject to a potential of 0 Volts. This space between the two cylinders does not have any accumulated charge. (i) What is the governing equation which decides the potential at any point in this region? (ii) Solve the above equation to find the potential at any point in this region. (iii) What is the electric field at any point in this region. (iv) Use the result in (iii) above to find the capacitance and resistance per unit axial length between the two cylinders.	[8]
	b)	Consider two concentric cylinders of radiuses 'a' and '$3a$'. The axial length of the cylinders vary from $z = 0$ to $z = l$. The volume current density distribution in the region $0 < z < l,\ a < \rho < 3a$ is given by: $\vec{J}(\rho, \varphi, z, t) = \hat{z}\cos(\omega t)\sin\left[\frac{\pi}{2}\frac{z}{l}\right] + \hat{\rho}\cos(\omega t)\cos\left[\frac{\pi}{2}\frac{\rho}{a}\right]$ (i) The volume charge density in this volume is zero at time $t = 0$. What is the volume charge density distribution at any time $t > 0$? (ii) What is the total charge within this volume at any time $t > 0$? (You may use the relation $\int_a^{3a}\sin\left[\frac{\pi}{2}\frac{\rho}{a}\right]\rho d\rho = -\frac{8a^2}{\pi^2}$)	[4+6]

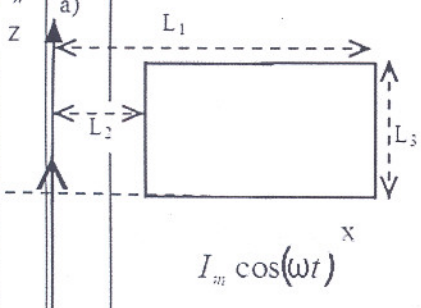
c) 

A block made of a perfect conductor is subject to an electric field as shown in the diagram. Explain the behavior of the free electrons within the conductor. Thereby explain how the internal electric field will set up. [2]

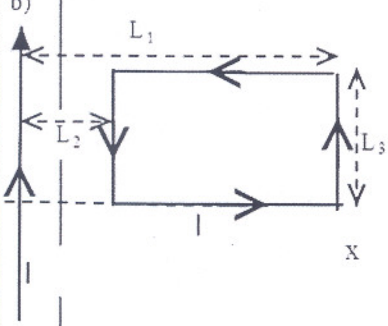
3. a) Consider a vector field $A(r,\theta,\varphi)$. Derive the radial component of $\nabla \times A$, that is, derive $(\nabla \times A)_r$. Show the relevant diagram. [7]

b) Consider a long line carrying a uniform electric current I ampere. Let this line be along the 'z' axis. Consider a planar 'window' at $y = 1$, stretching from $z = 1$ to 2, and $x = 2$ to 3. Find the total magnetic flux passing through this window. [6]

c) The surface current density on a square surface area is given by $K = \hat{x}x'y' + \hat{y}x'y'$. This surface area is on the $z = 0$ plane and stretches from $x' = 0$ to 1 and $y' = 0$ to 1. Derive an expression for the magnetic vector potential in the rectangular coordinate system for an observation point which is at $(0,0,1)$. [7]

4. a) 

An infinitely long wire along the z axis carries an alternating current $I_m \cos(\omega t)$. A rectangular coil stretching from $x = L_1$ to $x = L_2$ and breadth L_3 is placed on the x-z plane as shown. Derive the emf induced around the coil. [6]

b) 

An infinitely long wire along the z axis carries adirect current I. A rectangular coil stretching from $x = L_1$ to $x = L_2$ and breadth L_3 is placed on the x-z plane as shown. This coil also carries a direct current I in the anticlockwise direction. Find the force acting on the coil. [5]