Sheet 9

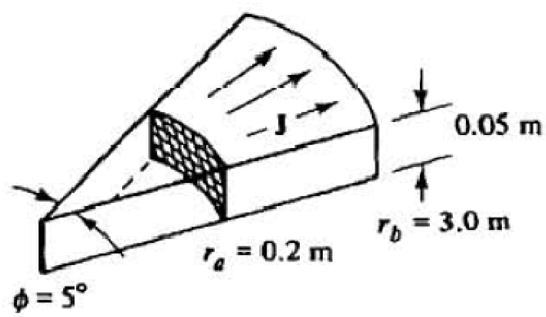
1 Two perfectly conducting spherical surfaces located at $r = 2$ and $r = 10$ cm, the total current passing radically outward through the medium between the spheres is 2.5 A

(a) Find the voltage and resistance between the spheres, and $\bar{E}$ in the region between the spheres, if a conducting material having $\sigma = 0.02\ \Omega^{-1}$/m is present for $2 < r < 10$ cm.

(b) Repeat if $\sigma = \dfrac{0.001}{r}$ $(\Omega\text{m})^{-1}$ for $2 < r < 10$ cm

$$\left[\begin{array}{l} V_{ab} = 397.88\ \text{V} \ ,\ R = 159.155\,\Omega \ ,\ \bar{E} = \dfrac{397.88}{r^2}\,\bar{a}_r \ \ \text{V/m} \\ V_{ab} = 320.1875\ \text{V} \ ,\ R = 128.0745\,\Omega \ ,\ \bar{E} = \dfrac{198.943}{r}\,\bar{a}_r \ \ \text{V/m} \end{array}\right]$$

2 Find the resistance between the inner and outer curved surfaces of the block shown figure



$$[R = 10.058\ \mu\Omega]$$

3 The potential $V = 2x^2 + 4y - 2z^2$ volts exists in free surrounding a perfectly conducting surface. Point (4,3,2) lies on the surface.

(a) Give the equation of the surface and f

(b) Find the unit vector normal to the surface at P

(c) Find ρ_s at point P

$$\left[2x^2 + 4y - 2z^2 = 36 \ ,\ \bar{a}_E = \frac{-4\bar{a}_x - \bar{a}_y + 2\bar{a}_z}{\sqrt{21}} \ ,\ \rho_s = 0.162\ \text{nC/m}^2\right]$$

4 Given the potential $\boldsymbol{V = (200/r^2) \sin\theta \cos\phi}$ volts

(a) Find the equation of the conducting surface on which $V = 100$ volts

(b) Find the electric field at point (r,30°,30°) on the conducting surface

(c) Find ρ_s at point P

$$\begin{bmatrix} \mathbf{1 = \left(\frac{2}{r^2}\right) \sin\theta \cos\phi} \\ \boldsymbol{\bar{E} = 248.646\left(\frac{\sqrt{3}}{2}\bar{a}_r - \frac{3}{4}\bar{a}_\theta + \frac{1}{2}\bar{a}_\phi\right)} \\ \boldsymbol{\rho_s = 2.75\ nC/m^2} \end{bmatrix}$$

5 Derive an expression for the electric field intensity of the electric dipole. Sketch the field mapping using streamlines equation

6 Explain the “Method of images” showing how this method had been inspired by the electric dipole

7 For a point charge $Q = 25$ nC lies at (3,4,6)

(a) Find $\bar{E}$ at (2,1,0)

(b) Find ρ_s at (2,1,0) when a grounded conducting plate is places at $z = 0$

(c) Find ρ_s at (4,5,3) when the plate of (b) is moved to $z = 3$

$$\begin{bmatrix} \boldsymbol{\bar{E} = -0.72\ \bar{a}_x - 2.16\ \bar{a}_y - 4.32\ \bar{a}_z} \\ \boldsymbol{\rho_s = 0.076\ \mathrm{nC/m^2}} \\ \boldsymbol{\rho_s = 0.327\ \mathrm{nC/m^2}} \end{bmatrix}$$

8 The electric field intensity is given by $\bar{E} = 5\, e^{2x}\left[\sin 2y\ \bar{a}_x - \cos 2y\ \bar{a}_y\right]$

(a) Find the equation of the streamline through P $(0.5\ , \frac{\pi}{10}\ , 0)$

(b) Find a unit vector tangent to the streamline at P

$$\begin{bmatrix} \boldsymbol{\cos 2y = 0.353\ e^{2x}} \\ \boldsymbol{\bar{a}_E = 0.6\bar{a}_x - 0.8\bar{a}_y} \end{bmatrix}$$

9 (a) If a finite line charge $\rho_L = 25\ \mathrm{nC/m}$ is extended from (3,4,3) to (3,4,5) find the electric field at (0,0,0)

(b) If a grounded conducting plane is placed at $z = 0$, find $\bar{E}$ at (0,0,0)

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10 An infinite line charge $\rho_L = 20\ \mathrm{nC/m}$, is located at $x = 0$ and $z = 3$, find ρ_s at (2,5,1) on a ground conducting plate placed at $z = 1$