The University of Jordan **Summer 2013**
EE251, Electromagnetics
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Seat No

Provide sketches and label all vectors and elements, and show your work in detailed steps for credit

1) Given the position vector from origin to the point P(1, 1, 0) meters. Express the vector in (use inspection and drawing and transformation)(4 pts)

a- cylindrical coordinates

$\rho = \sqrt{x^2+y^2} = \sqrt{2}$ | Victoria:

$\phi = \tan^{-1}(1) = \frac{\pi}{4}$

$z = 0$

$\vec{V}\left(\frac{2}{\sqrt{2}}, 0, 0\right)$

b- spherical coordinates

$\theta = \tan^{-1}\left(\frac{\sqrt{2}}{0}\right) = \frac{\pi}{2}$

$\phi = \tan^{-1} 1 = \frac{\pi}{4}$

$R = \sqrt{x^2+y^2+z^2} = \sqrt{2}$

$\left(\sqrt{2}, 0, 0\right)$

$\hat{x} = \hat{R}\sin\theta\cos\phi - \hat{\theta}\sin\phi + \hat{\theta}\cos\theta\cos\phi$

$\hat{y} = \hat{R}\sin\theta\sin\phi + \hat{\theta}\cos\theta\sin\phi$

$\hat{z} = 0$

$\hat{x} = \hat{\rho}\cos\phi - \hat{\phi}\sin\phi$

$\hat{y} = \hat{\rho}\sin\phi + \hat{\phi}\cos\phi$

$\hat{x}+\hat{y} = \frac{1}{\sqrt{2}}\hat{\rho} - \frac{1}{\sqrt{2}}\hat{\phi} + \frac{1}{\sqrt{2}}\hat{\rho} + \frac{1}{\sqrt{2}}\hat{\phi}$

$= \frac{2}{\sqrt{2}}\hat{\rho}$

$\hat{x}+\hat{y}+\hat{z} = \frac{1}{\sqrt{2}}\hat{R} - \frac{1}{\sqrt{2}}\hat{\phi} + \frac{1}{\sqrt{2}}\hat{R} + \frac{1}{\sqrt{2}}\hat{\phi} + 0$

2) Given the vector v = 1z meter, from point P(0, 1, 0), express in (use inspection and drawing and transformation) (4 pts)

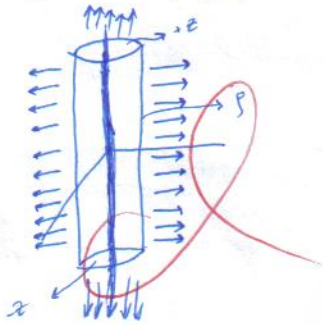
a- cylindrical coordinates

b- spherical coordinates

3) An infinite line of charge of 1 C/m is placed on the z axis.

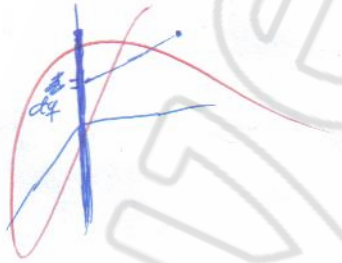
a) State Gauss law in few words. Express Gauss law mathematically (1 pts)

b) Sketch a diagram to be used with Gauss law, clearly label all required surfaces and vectors. (2 pts)



c)Using Gauss law find the electric field at any point from this line (3 pts)

d) Sketch a diagram to be used with Coulombs law (2 pts)



e) Using Coulomb's law, find E everywhere (3 pts)

$$E = \frac{\rho_L}{4\pi\varepsilon_0} \int \frac{dL}{R^3} \bar{R} = \frac{\rho_L}{4\pi\varepsilon_0}$$

e) The line is placed parallel to the y axis passing through the point (-1, 0, 1), find the electric field everywhere (2 pts)

4) Given $\mathbf{E} = 2z\,y\,\mathbf{x} + 3\,x\,y\,z\,\mathbf{y} + \mathbf{z}$ mV/m. (3 pts)

a) Find the charge density everywhere

$$\nabla \cdot \mathbf{E} = \rho_v$$

$$\frac{d}{dx}(2zy) + \frac{\partial}{\partial y}(3xyz) + \frac{\partial}{\partial z}(z) = 3xz + 1$$

$$\rho_v(x, y, z) = 3xz + 1$$

b) What is the total charge enclosed in a 1 cubic meter cube box centered at origin?

$$Q = \int dq = \int \rho_v \, dV$$

$$= \int_{-0.5}^{0.5}\int_{-0.5}^{0.5}\int_{-0.5}^{0.5} 3xz + 1 \, dx\,dy\,dz$$

$$= \int_{-1/2}^{1/2}\int_{-1/2}^{1/2}\left[\frac{3}{2}x^2z + x\right]_{-1/2}^{1/2} dy\,dz = \int_{-1/2}^{1/2}\int_{-1/2}^{1/2} yz + y \Big|_{-1/2}^{1/2} dz$$

$$= \int_{-1/2}^{1/2}\int_{-1/2}^{1/2} 1 \, dy\,dz = 1\ \text{C}$$

c) Find the flux passing through the plane of constant ρ

5) Given $\mathbf{E} = 2\,\mathbf{z}$ mV/m for $z>0$ and $\mathbf{E} = -2\,\mathbf{z}$ mV/m for $z<0$. (4 pts)

a) Find the charge density everywhere

$D = \varepsilon_0 E$

b) What is the total charge enclosed in a 1 cubic meter cube box centered at (0,0,10)m?

6) Consider a point charge of q Coulombs at the origin

a- Express Coulomb's law (1 pt)

b- Express the potential due to the charge (1 pt)

c- Show that the field is conservative (4 pts)

d- find total work done in moving 1 Coulomb charge around a circular path centered at origin at radius r using the path integral (4 pts)