University of Jordan

Faculty of Engineering & Technology

Department of Electrical Engineering

Course Title: Electromagnetics I		Exam: 1^{st} Exam	Date: Nov/03/2015
Course No.: 0903251	Semester: 1^{st} Term 2015-2016		Time Period: 1:00 Hr.
Instructor: Dr. Ahmad Atieh & Dr Yanal Faouri			

Q.1	Q.2	Total /20
2	8	10/20

* اللهم لا سهل إلا ما جعلته سهلا وأنت تجعل الحزن إذا شئت سهلا *

Student Name: [redacted]

Student Number: [redacted]

Section: 9-10 Dr. Ahmad Atieh

$$\nabla \cdot \mathbf{A} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

$$d\mathbf{S} = \rho\, d\phi\, dz\, \mathbf{a}_\rho \qquad d\rho\, dz\, \mathbf{a}_\phi \qquad \rho\, d\phi\, d\rho\, \mathbf{a}_z$$

$$\nabla \times \mathbf{A} = \frac{1}{\rho}\begin{vmatrix} \mathbf{a}_\rho & \rho\, \mathbf{a}_\phi & \mathbf{a}_z \\ \frac{\partial}{\partial \rho} & \frac{\partial}{\partial \phi} & \frac{\partial}{\partial z} \\ A_\rho & \rho A_\phi & A_z \end{vmatrix}$$

$$d\mathbf{l} = d\rho\, \mathbf{a}_\rho + \rho\, d\phi\, \mathbf{a}_\phi + dz\, \mathbf{a}_z$$

$$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$$

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Note that bold letters are vectors

Q1)

Find the following for the vector field **A**?

$\mathbf{A} = \rho^2 cos\,(\phi)\,\mathbf{a}_\rho - \rho sin\,(\phi)\,\mathbf{a}_\phi - 5\rho z^2\,\mathbf{a}_z$.

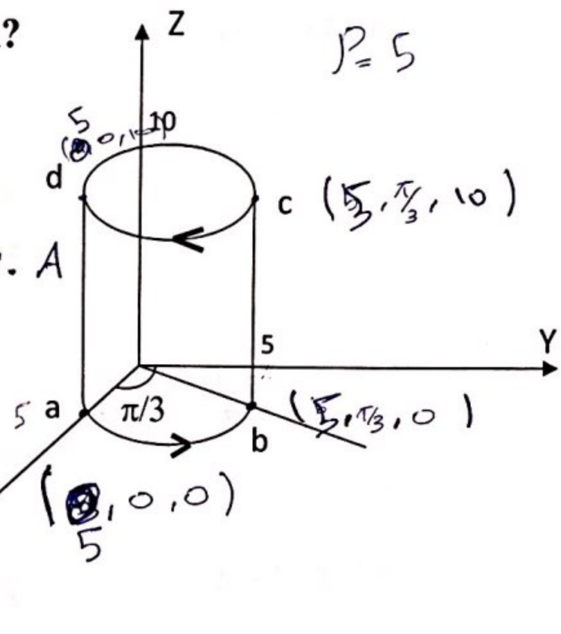
a) Is the vector **A** solenoidal? ∇

b) Is the vector **A** conservative? Div. A

c) Calculate the circulation of **A**

along the path **abcd** shown below?

$\rho = 5$



(a) No, it's A Vector

~~No Because it's A Vector & you Can't do the Gradient~~

(b)

$$\nabla\cdot A = \frac{1}{\rho}\frac{d}{d\rho}(\rho^3\cos(\phi))\,\vec{a_\rho} + \frac{1}{\rho}\frac{d\,\rho\sin(\phi)}{d\phi}\,\vec{a_\phi} - \frac{d\,5\rho z^2}{dz}\,\vec{a_z}$$

$$= 3\rho\cos(\phi)\,\cancel{a_\rho} - \cos(\phi)\,\cancel{a_\phi} - 10\rho z\,\cancel{a_z}$$

No, it's Not Conservative field because the div Does not Equal Zero

2/3

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$$A = \rho^2 \cos(\phi)\, \vec{a_\rho} + \rho \sin(\phi)\, \vec{a_\phi} - 5\rho z^2 \vec{a_z}$$

$$|\nabla \times A| = \frac{1}{\rho}\begin{vmatrix} \vec{a_\rho} & -\rho\vec{a_\phi} & \vec{a_z} \\ \frac{d}{d\rho} & \frac{d}{d\phi} & \frac{d}{dz} \\ \rho^2\cos(\phi) & -\rho\sin(\phi) & -5\rho z^2 \end{vmatrix}$$

1.0

$$= (0 - 0)\vec{a_\rho} - \rho(-5z^2 - 0)\vec{a_\phi} + \left(-\sin(\phi) + \rho^2 \sin(\phi)\right) a_z$$

$$= + 5\rho z^2\, \vec{a_\phi} + \left(-\sin(\phi) + \rho^2 \sin\phi\right)\vec{a_z}$$

Zero

$$\int_{\phi=0}^{\pi/3}\int_{\rho=}^{a} \cancel{5\rho z^2} + (-\sin(\phi) + \rho^2 \sin\phi)\,\rho\, d\rho\, d\phi \Big|_{z=0}$$ 0.5

$$+ \int_{z=\text{zero}}^{10}\int_{\rho=b}^{c} 5\rho z^2 + (-\sin(\phi) + \rho^2 \sin\phi)\, d\rho\, dz \Big|_{\phi=\pi/3}$$

$$+ \int_{\phi=\pi/3}^{0}\int_{\rho=c}^{d} 5\rho z^2 + \left(-\sin(\phi) + \rho^2 \sin\phi\right)\rho\, d\rho\, d\phi \Big|_{z=10}$$

$$+ \int_{z=10}^{0}\int_{\rho=d}^{a} 5\rho z^2 + \left(-\sin(\phi) + \rho^2 \sin(\phi)\right) d\rho\, dz \Big|_{\phi=0}$$

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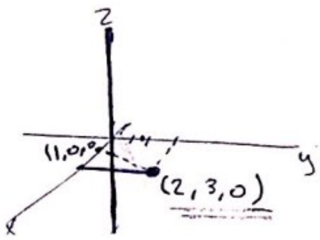
Q2)

A uniform line charge density $\rho_\ell = 1\ \text{nCm}^{-1}$ of an infinite length is placed along the z-axis in free space and an electric charge $Q_1 = 1$ nC is placed at (1, 0, 0). Find the electric flux density at point P(2, 3, 0).

$\vec{E}_{\text{on } P} = \vec{E}_{Q_1} + \vec{E}_{\rho_\ell}$



$\vec{E}_{Q_1} = \dfrac{Q}{4\pi\varepsilon_0 \left|(2,0,3)-(1,0,0)\right|^3}\left((2,3,0)-(1,0,0)\right)$

$= \dfrac{10^{-9}}{(4\pi\varepsilon_0)\times(31.62)}\left(\vec{a_x} + 3\vec{a_z}\right)$

$$\boxed{E_{Q_1} = 0.284\,\vec{a_x} + 0.852\,\vec{a_z}}$$

$\vec{E}_{\text{infinite line}} = \dfrac{\rho_\ell}{2\pi\varepsilon_0\rho}\vec{a_\rho}$

$E = \dfrac{Q}{4\pi\varepsilon_0 R^2}\vec{a_R}$

change

$E = \dfrac{Q\,\vec{R}}{4\pi\varepsilon_0 R^3}$

$\vec{a_\rho} = \dfrac{\vec{\rho}}{|\rho|}$

$E = \dfrac{\rho_\ell}{2\pi\varepsilon_0\rho}\vec{a_\rho}$

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

$= \sqrt{4+9}$

$= \dfrac{10^{-9}}{2\pi\varepsilon_0 \times 13)}\left[3.6\,\vec{a_\rho} + 0.98\,\vec{a_\phi}\right]$

$\phi = \tan^{-1}\left(\frac{y}{x}\right) = 0.98°$

ρ^2

$= 1.382\left[3.6\,\vec{a_\rho} + 0.98\,\vec{a_\phi}\right]$

$\boxed{z=0}$

$$\boxed{E_\rho = 4.98\,\vec{a_\rho} + 1.3543\,a_\phi}$$

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