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الفصل الخامس

College of Electronic Technology

Electromagnetic I-2020

Time: 120 minutes **final Exam** **Total Marks is (60)**

Answer these questions as the best of your knowledge:

Q1) (a) State Maxwell's equations for static EM fields?

(b) Find the maximum rate of change in scalar field:

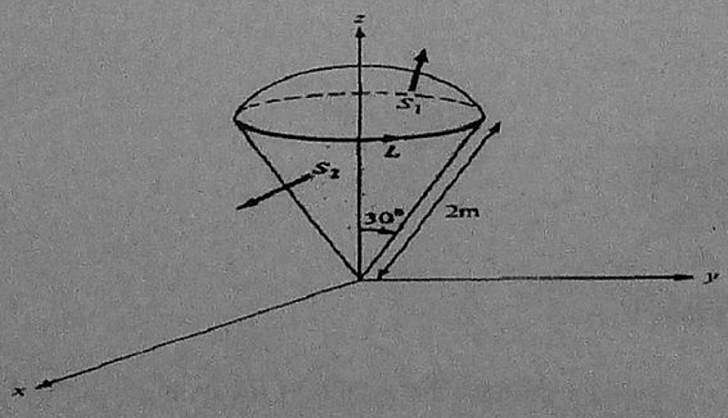
$$W = 10r \sin^2\theta \cos\phi$$

Q2) Let $\mathbf{A} = \rho \cos\theta\, \mathbf{a}_\rho + \rho z^2 \sin\phi\, \mathbf{a}_z$

(a) Transform $\mathbf{A}$ into rectangular coordinates and calculate its magnitude at point $(3, -4, 0)$.

b) If **A** is soleniodal at Z plane what is the value of ø should be?

(c) For the ice-cream cone Fig-d express *dl. ds1. ds2*?



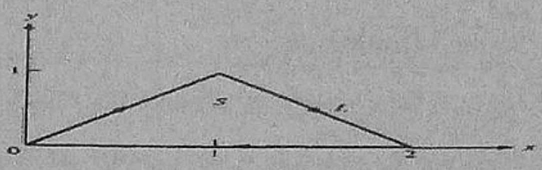
Q3)

Given that $\mathbf{F} = x^2y\,\mathbf{a}_x - y\,\mathbf{a}_y$, find

(a) $\oint_L \mathbf{F} \cdot d\mathbf{l}$ where L is shown in Figure 3.29.

(b) $\int_S (\nabla \times \mathbf{F}) \cdot d\mathbf{S}$ where S is the area bounded by L.

(c) Is Stokes's theorem satisfied?



Q4)

In a certain region, the electric field is given by

$$\mathbf{D} = 2\rho(z + 1)\cos\phi\,\mathbf{a}_\rho - \rho(z + 1)\sin\phi\,\mathbf{a}_\phi + \rho^2\cos\phi\,\mathbf{a}_z\ \mu\text{C/m}^2$$

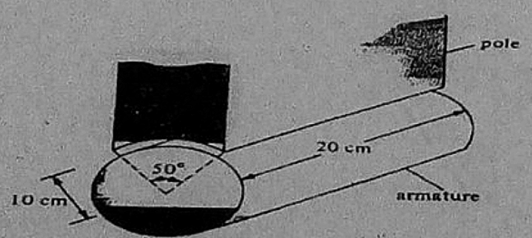
(a) Find the charge density.

(b) Calculate the total charge enclosed by the volume $0 < \rho < 2$, $0 < \phi < \pi/2$, $0 < z < 4$.

(c) Confirm Gauss's law by finding the net flux through the surface of the volume in (b).

Q5) The electric motor shown in Figure 7.32 has field

$$\mathbf{H} = \frac{10^6}{\rho}\sin 2\phi\,\mathbf{a}_\rho\ \text{A/m}$$



(a)

Calculate the flux per pole passing through the air gap if the axial length of the pole is 20 cm.

(b) Determine **J** at (1, 45, 0) **(c)** Determine **B**

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the end of question

4

(a) $\rho_v = \nabla \cdot \bar{D} = 4(z+1)\cos\phi - (z+1)\cos\phi + 0$

$= 3(z+1)\cos\phi \ \mu C/m^2$

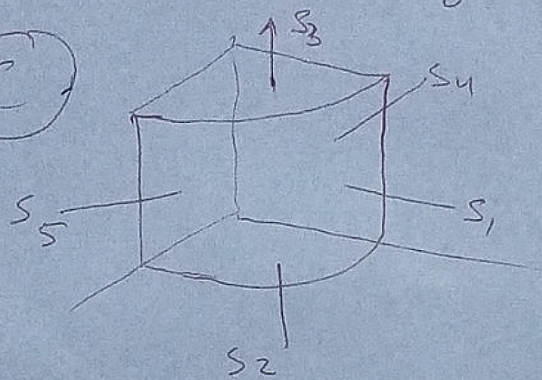
(b) $Q_{enc} = \int \rho_v \, dv = \iiint 3(z+1)\cos\phi \, \rho \, d\phi \, d\rho \, dz$

$= 3\int_0^2 \rho \, d\rho \int_0^4 (z+1) \int_0^{\pi/2} \cos\phi \, d\phi = 3(2)\left(\frac{z^2}{2}+z\right)\Big|_0^4$

$(\sin\phi|_0^{\frac{\pi}{2}}$ $= \boxed{72 \mu C}$

12 marks

(c)



$\psi = \psi_1 + \psi_2 + \psi_3 + \psi_4 + \psi_5$

$= \oint \bar{D} \cdot d\bar{s}$

الفيض الناشئ من كل سطح

for $S_1 \rightarrow \rho = 2$, $d\bar{s} = \rho \, d\phi \, dz \, \bar{a}_\rho$

$\therefore \psi_1 = \iint 2\rho(z+1)\cos\phi \big|_{\rho=2} = 2(2)\int_0^4 (z+1)dz \int_0^{\pi/2} \cos\phi \, d\phi$

$= 4(12)(1) = \boxed{48}$

For $S_2 \Rightarrow z = 0$, $d\bar{s} = \rho \, d\phi \, d\rho \, (-\bar{a}_z)$

$\psi_2 = -\iint \rho^2 \cos\phi \cdot \rho \, d\phi \cdot d\rho = -\int_0^2 \rho^3 d\rho \int_0^{\pi/2} \cos\phi \, d\phi$

$= -\frac{\rho^4}{4}\Big|_0^2 (1) = \boxed{-4}$

For $S_3 \Rightarrow z = 1$, $d\bar{s} = \rho \, d\phi \, d\rho \, \bar{a}_z \Rightarrow \psi_3 = \boxed{4}$

for $S_4 \Rightarrow \phi = \frac{\pi}{2}$, $d\bar{s} = d\rho \, dz \, \bar{a}_\phi$

$\psi_4 = \iint \rho(z=4) \sin\phi \, d\rho \, dz \big|_{\phi=\frac{\pi}{2}} = (1)\int_0^2 \rho \, d\rho \int_0^4 (z+1)$

$= \boxed{-24}$

for $S_5 \rightarrow \phi = 0$, $d\bar{s} = d\rho \, dz \, (-\bar{a}_\phi)$, $\psi_5 = \iint \rho(z$

$\sin\phi \, d\rho \, dz \big|_{\phi=0}$ $\boxed{= 0}$

$\boxed{2}$

$\psi_{total} = 24 \mu C$

د. ... ضياء (Arabic handwriting; partly illegible)

Electromagnetic I exam Solution
Spring 2019

(4)

Q1 (a) $\nabla\cdot\overline{D} = \rho_v$, $\nabla\cdot\overline{B} = 0$, $\nabla\times\overline{E} = 0$, $\nabla\times\overline{H} = J$

(b) $\nabla W = 10\sin^2\theta\cos\phi\,\overline{a_r} + 10\sin 2\theta\cos\phi\,\overline{a_\theta} - 10\sin\theta\sin\phi\,\overline{a_\phi}$ (3)

The gradient

12 marks

~~(c)~~ Solenoidal $\rightarrow \nabla\cdot\overline{A} = 0$, potential $\rightarrow \nabla\times A = 0$

Q3 (a) $\oint_l \overline{F}\cdot\overline{dl} = \left(\int_1 + \int_2 + \int_3\right)\overline{F}\cdot\overline{dl}$

at (1) $y = x$, $dy = dx$, $dl = dx\,\overline{a_x} + dy\,\overline{a_y}$

$\therefore \int_1 \overline{F}\cdot\overline{dl} = \int x^3\,dx - x\,dx = \boxed{-\frac{1}{4}}$

at (2) $y = -x + 2$, $dy = -dx$, $dl = dx\,\overline{a_x} + dy\,\overline{a_y}$

$\therefore \int_2 \overline{F}\cdot\overline{dl} = \int_1^2 (-x^3 + 2x^2 - x + 2)\,dx = \boxed{\frac{17}{12}}$

at (3) $\int_3 \overline{F}\cdot\overline{dl} = \int_2^0 x^2\,y\,dx\Big|_{y=0} = 0$, $\Rightarrow \boxed{\frac{7}{6}}$

(b) $\nabla\times\overline{F} = -x^2\,\overline{a_z}$, $\overline{ds} = dx\,dy\,(-\overline{a_z})$

$\int(\nabla\times\overline{F})\cdot ds = -\iint(-x^2)\,dx\,dy = \int_0^1\int_0^x x^2\,dy\,dx$

$+ \int_1^2\int x^2\,dy\,dx = \frac{x^4}{4}\Big|_0^1 + \int_1^2 x^2(-x+2)\,dx = \frac{7}{6}$

12 marks

(c) Yes ~~satisfied~~

Q3 (a) $\psi = \int \bar{B} \cdot \bar{ds} = \mu_0 \int_{z=0}^{0.2} \int_{\phi=0}^{50^\circ} \frac{10^6}{\rho} \sin 2\phi \, \rho \, d\phi \, dz$

$\psi = 4\pi \times 10^{-7} \times 10^6 (0.2) \left(- \frac{\cos 2\phi}{2} \right) \Big|_0^{50^\circ}$

$\psi = 1.1475 wb$

12 marks

(b) $J = \nabla \times \bar{H}$

$= [0 - 0] \bar{a}_\rho + [0 - 0] a_\phi$

$+ \frac{1}{\rho} [0 - \frac{2 \cdot 10^6}{\rho} \cos 2\phi] = - \frac{2 \times 10^6}{\rho^2} \cos 2\phi \cdot a_z$

(c) $\bar{B} = \mu_0 \bar{H} = \frac{4\pi \times 10^{-7} \times 10^6}{\rho} \sin 2\phi \, \bar{a}_\rho$

$\bar{B} = \frac{4\pi}{10\rho} \sin 2\phi \, \bar{a}_\rho$.

End

Q2 $ds_1 = r \sin\theta \, d\phi . \, r d\theta . \, \hat{a}_r = r^2 \sin\theta . d\phi \, d\theta . \hat{a}_r$

c $d\ell = r . \sin\theta \, d\phi . \hat{a}_\phi = r . \sin 30 . d\phi . \hat{a}_\phi = \frac{r}{2} d\phi . \hat{a}_\phi$

$ds_2 = r . \sin\theta . d\phi . dr . \hat{a}_\theta = r . \frac{1}{2} . d\phi . dr . \hat{a}_\theta$

12 marks