Midterm examination

Electromagnetic.

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class : CTTT TĐH & HT Điện 02 - K64 (EE-E8(02)).

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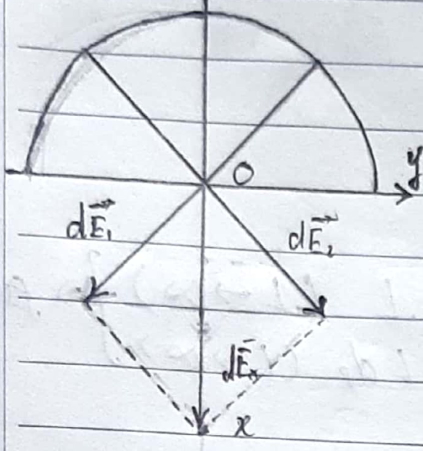
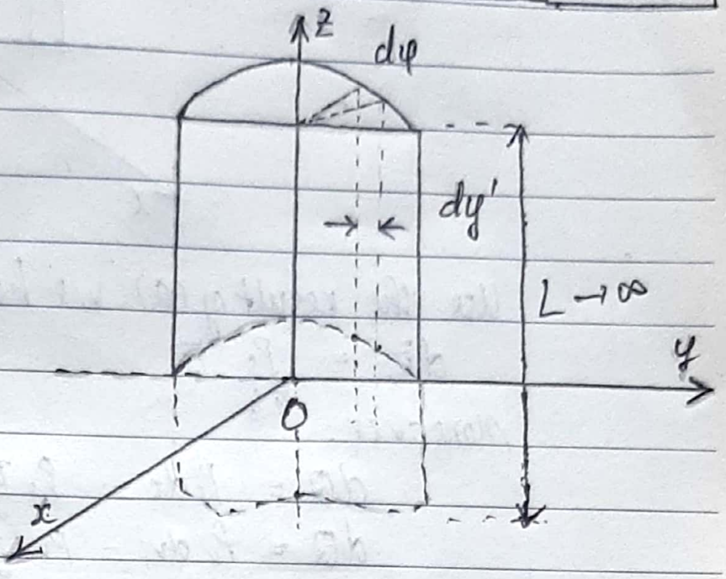
Question 1:





We assume that the infinity semicylinder lies on (yz-plane, negative x), and the axis of the cylinder is z axis.

a, we have:

$d\bar{E} = \dfrac{\rho_L \bar{a}_\rho}{2\pi \varepsilon R}$; $dQ = \rho_s ds = \rho_s L\, dy'$ $(L \to \infty)$

$dy' = d\varphi . R.$

$\rightarrow \rho_L = \dfrac{dQ}{L} = \dfrac{\rho_s L\, dy'}{L} = \rho_s dy'$

$\rightarrow dE = \dfrac{\rho_s dy'}{2\pi \varepsilon_0 R} = \dfrac{\rho_s d\varphi R}{2\pi \varepsilon_0 R} = \dfrac{\rho_s d\varphi}{2\pi \varepsilon_0}$

$dE_x = dE_1 \sin\varphi + dE_2 \sin\varphi = 2 dE \sin\varphi$ $(dE = dE_1 = dE_2)$

$\rightarrow dE_x = \dfrac{2\rho_s \sin\varphi\, d\varphi}{2\pi\varepsilon_0} = \dfrac{\rho_s \sin\varphi\, d\varphi}{\pi\varepsilon_0}$

$E_x = \int_0^{\frac{\pi}{2}} \dfrac{\rho_s \sin\varphi\, d\varphi}{\pi\varepsilon_0} = -\dfrac{\rho_s \cos\varphi}{\pi\varepsilon_0}\Big|_0^{\frac{\pi}{2}} = \dfrac{\rho_s}{\pi\varepsilon_0}$

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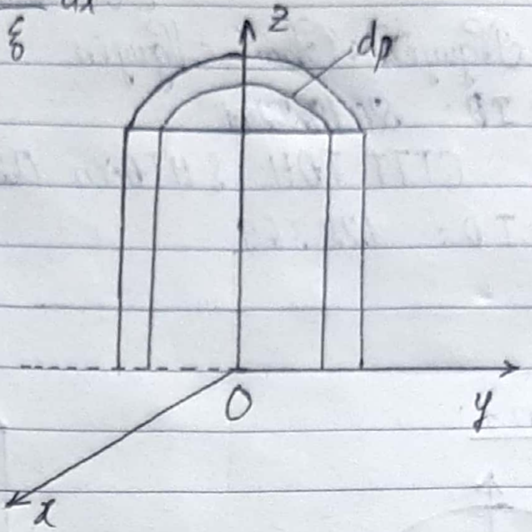
The electric field intensity along the axis of the cylinder

$$\bar{E}_x = \frac{\rho_s}{\pi \varepsilon_0} \bar{a}_x$$



Use the result of (a) we have:

$$d\bar{E}_x = \frac{\rho_s}{\pi \varepsilon_0} \bar{a}_x$$

Moreover:

$$dQ = \rho_s ds = \rho_s \frac{\pi 2}{2} . \rho . L \quad (L \to \infty)$$
$$dQ = \rho_v dv = \rho_v \frac{2\pi}{2} . \rho . L d\rho \quad (L \to \infty)$$
$$\Rightarrow \rho_s = \rho_v d\rho$$

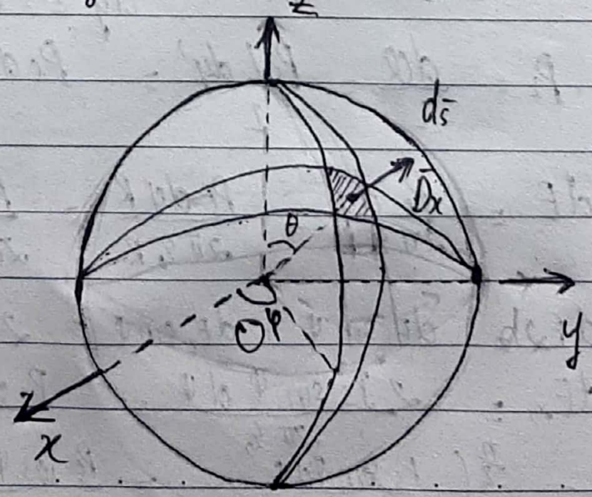
$$\Rightarrow dE = \frac{\rho_v d\rho}{\pi \varepsilon_0}$$

$$\Rightarrow E = \int_{\rho=0}^{R} \frac{\rho_v d\rho}{\pi \varepsilon_0} = \frac{\rho_v R}{\pi \varepsilon_0}$$

The Electric field intensity along the axis due to the uniform semicylinder: $\bar{E} = \frac{\rho_v R}{\pi \varepsilon_0} \bar{a}_x$

Question 2:

a, $E = AR\bar{a}_r$



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Gauss's law : $Q_{enclosed} = \oint_s D_s \, ds$

$\bar{D}_s = \bar{E}.\varepsilon_0 = A \varepsilon R \bar{a}_r$

$d\bar{s} = R^2 \sin\theta \, d\theta \, d\varphi \, \bar{a}_r$

(*) D_s perpendicular to the surface

$\Rightarrow Q_{enclosed} = \oint_s D_s \, d_s = D_s \oint ds$

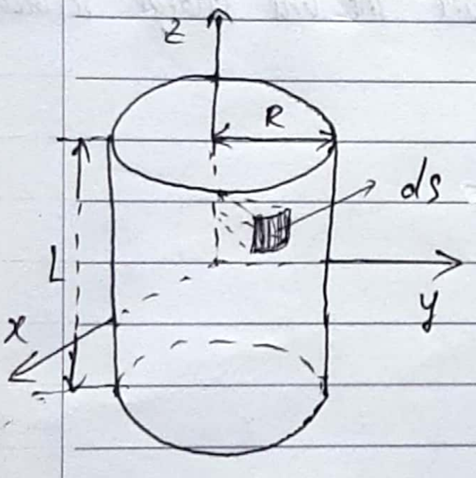
$= A \varepsilon_0 R \int_0^{2\pi} \int_0^{\pi} R^2 \sin\theta \, d\theta \, d\varphi = 4\pi A \varepsilon R^3$

Thus, the total charge enclosed

$Q_e = 4\pi \varepsilon A . R^3$

b,

$E = A . \rho^2 a_\rho$, for a cylinder of Radius R and length L



Gauss 'law :

$Q_{enclosed} = \oint \bar{D}_s \, d\bar{s}$

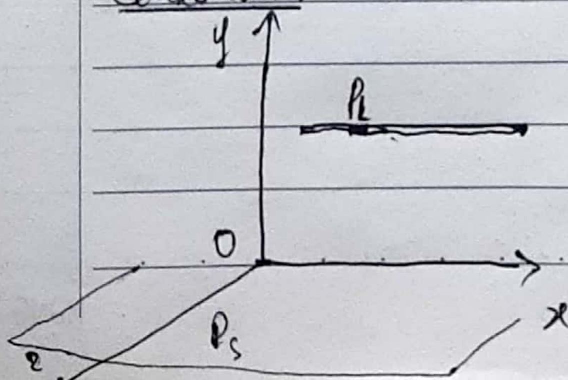
$= D_s \int_{sides} d_s + 0 \int_{top} d_s + 0 \int_{bottom} d_s$

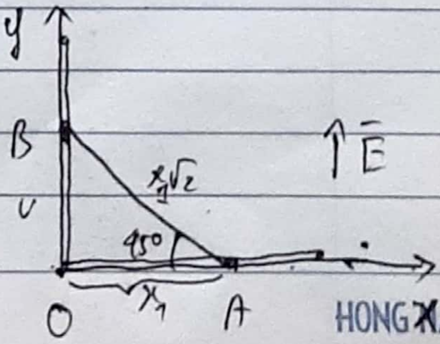
$Q_{enclosed} = D_s \int_{z=0}^{L} \int_{\varphi=0}^{\varphi=2\pi} R \, d\varphi \, dz$

$= \varepsilon E 2\pi R L = \varepsilon A . R^2 . 2\pi R . L$

$= 2\pi R^3 \varepsilon L .$

Question 3 :





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Suppose the sheet charge is in the xz-plane and the line charge is on the Ox axis.

we have the EFI due to the sheet of charge is.

$$\bar{E} = \frac{\rho_s}{2\varepsilon_0}\bar{a}_y$$

$$dw = -Q\bar{E}.\bar{L}_{AB} \; ; \; (L_{AB} = AB = x_1\sqrt{2})$$

$$\Rightarrow dw = \frac{-\rho_L \rho_s \sqrt{2}\, x_1}{2\varepsilon_0}\cos 45 = -\frac{\rho_L \rho_s x_1}{2\varepsilon_0}$$

$$\Rightarrow W = \int_0^L dw = \int_0^L -\frac{\rho_L \rho_s\, x\, dx_1}{2\varepsilon_0} = -\frac{\rho_L \rho_s x_1^2}{4\varepsilon_0}\Big|_0^L$$

$$= \frac{-\rho_L \rho_s L^2}{4\varepsilon_0}$$

The work is required to rotate the line charge so that it is vertical:

$$W = -\frac{\rho_L \rho_s L^2}{4\varepsilon_0}$$