No.

Date :

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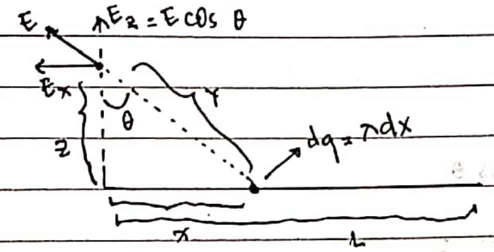
Kelistrikan dan Kemagnetan.

1) Muatan terdistribusi pada garis dengan panjang tertentu (L), muatan seragam Q terletak di sepanjang garis yang panjangnya L, terletak pada sepanjang sumbu x dari $x = 0$ sampai $x = L$, densitas muatanya adalah $Q = \lambda L$. Hitung medan listrik pada titik P yang terletak pada $X_0 > L$!



$$\vec{E} = \vec{E}_z + \vec{E}_x$$

$$E_z = \frac{1}{4\pi\epsilon_0}\int_0^L d\vec{E}\cos\theta$$

Ambil $\vec{E}_z = \frac{1}{4\pi\epsilon_0}\int_0^L \frac{dq}{r^2} = \frac{1}{\square}\int_0^L \frac{\lambda\,dx}{r^2}\cos\theta$, $\cos\theta = \frac{z}{r}$

$$\vec{E}_z = \frac{1}{\square}\int_0^L \frac{z\lambda\,dx}{r^3} = \frac{1}{\square}\int_0^L \frac{z\lambda\,dx}{(z^2+x^2)^{3/2}}$$

$$= \frac{z\lambda}{4\pi\epsilon_0}\int_0^L \frac{dx}{(z^2+x^2)^{3/2}}$$

Lihat di daftar Integral $\int_0^L \frac{dx}{(z^2+x^2)^{3/2}} = \frac{1}{z^2}\frac{x}{\sqrt{z^2+x^2}}\Big]_0^L$

$$\vec{E}_z = \frac{1}{4\pi\epsilon_0}\lambda z\left[\frac{1}{z^2\sqrt{z^2+x^2}}\right. = \frac{\lambda}{4\pi\epsilon_0}\frac{L}{z\sqrt{z^2+x^2}}$$

$$\vec{E}_x = -\frac{1}{4\pi\epsilon_0}\int_0^L \frac{\lambda\,dx}{r^2}\sin\theta = -\frac{\lambda}{4\pi\epsilon_0}\int_0^L \frac{x\,dx}{(z^2+x^2)^{3/2}}$$

$$= -\frac{\lambda}{4\pi\epsilon_0}\cdot\frac{1}{2}\int_0^L \frac{dx^2}{(z^2+x^2)^{3/2}}$$

$$= -\frac{\lambda}{4\pi\epsilon_0}\frac{1}{2}\left[-2\frac{1}{(z^2+x^2)^{1/2}}\right]_0^L$$

$$= -\frac{\lambda}{4\pi\epsilon_0}\left[-\left(\frac{1}{\sqrt{z^2+x^2}} - \frac{1}{z}\right)\right]$$

$$\vec{E}_x = -\frac{\lambda}{4\pi\epsilon_0}\left[\frac{1}{z} - \frac{1}{\sqrt{z^2+x^2}}\right]$$

Jadi, $\vec{E} = \vec{E}_z + \vec{E}_x$.

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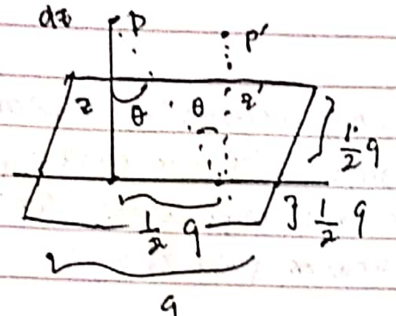
3). Hitung medan listrik sejauh z diatas kawat lurus panjang dengan rapat muatan persatuan panjang λ yang homogen.



$P = P' \cos\theta$, karena ada q sisi, maka
$P = 4P' \cos\theta$, sehingga

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\lambda L}{z' L} = 4 \cdot \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\lambda L}{z'z} \cos\theta$$

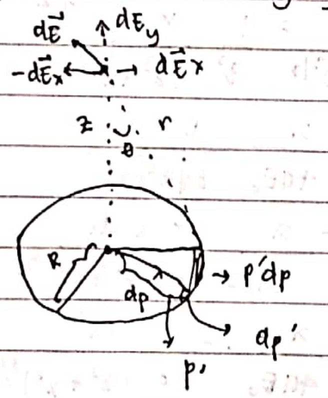
Karena $L = \frac{1}{2}q$, dan $z = r = \sqrt{z^2 + (\frac{1}{2}q)^2}$, $\cos\theta = \frac{z}{\sqrt{z^2 + (\frac{1}{2}a)^2}}$

Maka $$\vec{E} = 4 \cdot \frac{1}{4\pi\varepsilon_0} \frac{2\lambda(\frac{1}{2}q) \cdot z}{(z^2 + (\frac{1}{2}q)^2)\sqrt{z^2 + (\frac{1}{2}q)^2}}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\lambda q z}{(z^2 + \frac{q^2}{4})\sqrt{z^2 + \frac{q^2}{4}}}, z$$

4). Tentukan medan listrik berjarak z diatas permukaan ke bentuk lingkaran dengan jari-jari R yang membawa permukaan seragam.

Solusi :



* $ds = da = p \times \ell$
$= dp' \cdot p' d\phi$
$da = p' dr' d\phi$

* $$E' = \frac{1}{4\pi\varepsilon_0} \int \frac{\sigma\, da}{p^2} \cos\theta$$

$$d\vec{E} = d\vec{E}_y + d\vec{E}_x = 0$$
$$= dE \cos\theta$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int_0^R \int_0^{2\pi} \frac{r}{p^2} \cos\theta, \overbrace{r' ds' dp}^{da}$$

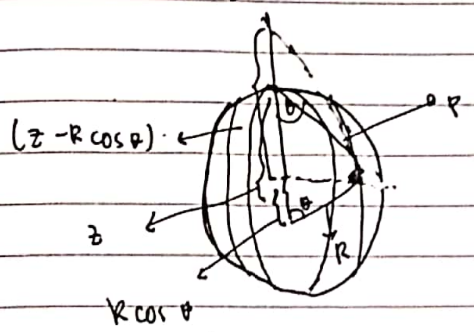
lalu buka $\cos\theta$ dengan p^2 sehingga menjadi

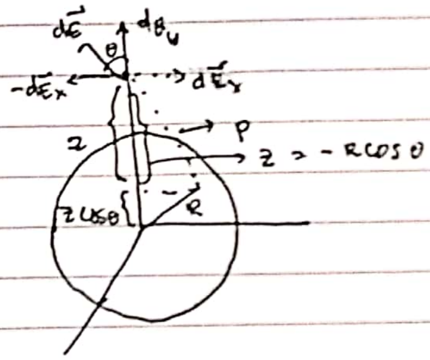
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \sigma z \int_0^R \int_0^{2\pi} \frac{p' \, dp' \, d\phi}{(p'^2 + z^2)^{3/2}},$$

$$= \frac{2\pi\sigma z}{4\pi\varepsilon_0}\int_0^R \frac{p'\,dr'}{(p'^2+z^2)^{3/2}}$$

$$= \frac{\sigma z}{2\varepsilon_0}\int_0^R \frac{1}{2}\,\frac{d(p'^2+z^2)}{(p'^2+z^2)^{3/2}}$$

4). Bola tipis bermuatan terdistribusi muatan. Hitung medan listrik sejauh z dari pusat lingkaran.





- $p = [(R\sin\theta)^2 + (z - R\cos\theta)^2]^{\frac{1}{2}}$

  $p = [R^2\sin\theta + (z^2 + R^2\cos^2\theta - 2Rz\cos\theta)^{\frac{1}{2}}$

  $P = R^2(\sin^2\theta + \cos^2\theta) + z^2 - 2Rz\cos\theta]^{\frac{1}{2}}$

  $P = (R^2 + z^2 - 2Rz\cos\theta)^{\frac{1}{2}}$

- $d\vec{E} = d\vec{E}_x + dE_y$

  $d\vec{E} = dE\, d\phi\, \theta$

  $$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int_0^{\pi}\int_0^{2\pi} \frac{\sigma\, da\cos\theta}{p^2}$$

  $$E = \frac{1}{4\pi\varepsilon_0}\int_0^{\pi}\int_0^{2\pi} \sigma\,\frac{(z - R\cos\theta)\,R^2\sin\theta\, d\theta\, d\phi}{(R^2+z^2-2Rz\cos\theta)^{3/2}}.$$