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Soal no 2.

Sebuah batang panjangnya l, rapat muatan per satuan panjang adalah λ.
Hitung :

a.) Kuat medan listrik di titik P yang berjarak z diatas ujung kawat.

b.) Kuat medan listrik dititik P yang berjarak di tengah-tengah kawat.

$\Rightarrow$ Penyelesaian :

a.) Diket : Batang panjang L
Rapat muatan linear λ
Titik P berada pd jarak z.

$\Rightarrow$ $x = 0$ sampai $x = L$ $\quad r^2 = \sqrt{x^2 + z^2}$

$$dE = \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda dx}{r^2}$$

$$dE_z = dE \cdot \cos\theta = \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda dx}{x^2 + z^2} \cdot \frac{z}{\sqrt{x^2 + z^2}} =$$

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

Integralkan dari $x = 0$ sampai $x = L$

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

$$\int_0^L \frac{dx}{(x^2+z^2)^{3/2}} = \left[\frac{x}{z^2\sqrt{x^2+z^2}} \right]_0^L = \frac{L}{z^2\sqrt{L^2+z^2}}$$

$$E_z = \frac{\lambda z}{4\pi\epsilon_0} \cdot \frac{L}{z^2\sqrt{L^2+z^2}} = \frac{\lambda L}{4\pi\epsilon_0\sqrt{L^2+z^2}}$$

$$E = \frac{\lambda L}{4\pi\epsilon_0\sqrt{L^2+z^2}}$$

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b.) titik P berada pada jarak z diatas titik tengah kawat.

$x = -L/2$ sampai $x = L/2$.

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

$$\int_{-a}^{a} \frac{dx}{(x^2+z^2)^{3/2}} = \frac{2a}{z^2\sqrt{a^2+z^2}}, \quad a = \frac{L}{2}$$

$$E_z = \frac{\lambda z}{4\pi\epsilon_0} \cdot \frac{2(L/2)}{z^2\sqrt{(L/2)^2+z^2}} = \frac{\lambda L}{4\pi\epsilon_0 z\sqrt{(L^2/4)+z^2}}.$$

$$E = \frac{\lambda L}{4\pi\epsilon_0 z\sqrt{(L^2/4)+z^2}}.$$

Soal no 3

Hitung medan listrik pada bolakonduktor dengan rapat muatan σ dan jari-jari R.

Penyelesaian:

$\Rightarrow \quad Q = \sigma . A$

$= \sigma . 4\pi R^2$

medan listrik di dalam = 0 $\rightarrow$ E(r) = 0 untuk $r < R$

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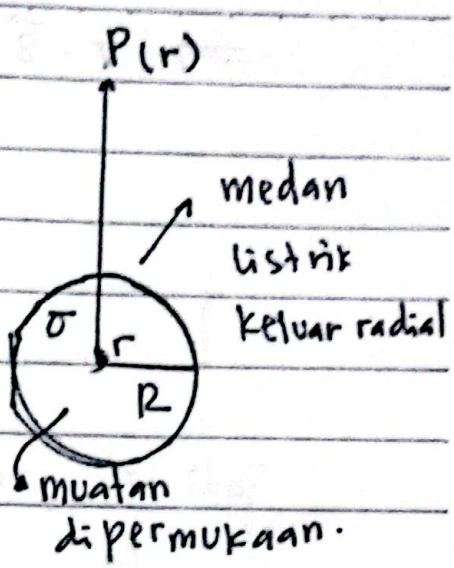
medan listrik diluar bola ($r \geq R$)

$$E \cdot 4\pi r^2 = \frac{Q}{\epsilon_0} \Rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2}$$



subtitusi $Q = \sigma \cdot 4\pi R^2$

$$E = \frac{\sigma 4\pi R^2}{4\pi\epsilon_0 r^2} = \frac{\sigma R^2}{\epsilon_0 r^2}.$$

Jadi $E(r) = \begin{cases} 0, & \text{untuk } r < R \\ \frac{\sigma R^2}{\epsilon_0 r^2}, & \text{untuk } r \geq R. \end{cases}$

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Soal no 4

diberikan medan listrik dalam bentuk :

$$\vec{E} = kr^3 \hat{r}$$

a.) Hitung rapat muatannya (ρ)

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

makan divergensinya :

$$\nabla \cdot \vec{E} = \frac{1}{r^2} \frac{d}{dx} (r^2 E_r)$$

subtitusikan $E_r = kr^3$.

$$\Rightarrow \nabla \cdot \vec{E} = \frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{} \cdot kr^3\right)$$

$$= \frac{1}{r^2}\frac{d}{dr}(kr^5)$$

$$= \frac{1}{r^2}(5kr^4) = 5kr^2.$$

jadi $\frac{\rho}{\epsilon_0} = 5kr^2 \Rightarrow \rho = 5k\epsilon_0 r^2$

$\rho(r) = 5k\epsilon_0 r^2.$

b.) Cari muatan total dalam bola berjari - jari R.

total muatan $\Rightarrow Q = \int_v \rho(r)\, dv.$

Gunakan integral volume koordinat bola.

$$Q = \int_0^R \int_0^{\pi} \int_0^{2\pi} (5k\epsilon_0 r^2) \cdot r^2 \sin\theta \, d\phi \, d\theta \, dr.$$

$$Q = 5k\epsilon_0 \int_0^R r^4 dr \cdot \int_0^{\pi} \sin\theta \, d\theta \cdot \int_0^{2\pi} d\phi$$

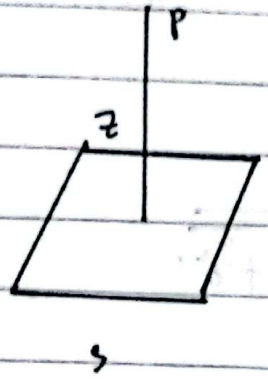
Evaluasi tiap integral

- $\int_0^R r^4 dr = \frac{R^5}{5}$
- $\int_0^{2\pi} d\phi = 2\pi.$
- $\int_0^{\pi} \sin\theta \, d\theta = 2$

maka $= Q = 5k\epsilon_0 \cdot \frac{R^5}{5} \cdot 2 \cdot 2\pi = 4\pi\epsilon_0 R^5$

soal no 5

Hitung medan listrik



Jawab :

$$E_x = \frac{1}{4\pi\epsilon_0} \frac{z\lambda}{r} \sin\theta$$

$$dE = \frac{1}{4\pi\epsilon_0} \frac{\lambda\, dx}{(x^2+z^2)} \cdot \frac{z}{\sqrt{x^2+z^2}}$$

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

integrasi dari $x = -s/2$ sampai $x = s/2$.

$$E_z^{(1 \text{ sisi})} = \frac{1}{4\pi\epsilon_0} \cdot \lambda z \cdot \frac{z(s/2)}{z^2\sqrt{(s/2)^2+z^2}} = \frac{1}{4\pi\epsilon_0} \cdot \frac{\lambda s}{z\sqrt{(s^2/4)+z^2}}$$

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totalkan semua :

$$E_z^{total} = 4 \cdot E_z^{(1\ sisi)} = \frac{4}{4\pi\epsilon_0} \cdot \frac{\lambda_s}{z\sqrt{(s^2/4)+z^2}} = \frac{1}{\pi\epsilon_0} \cdot \frac{\lambda_s}{z\sqrt{(s^2/4)+z^2}}$$

Jadi total medan listrik :

$$\Rightarrow \quad E_z = \frac{1}{\pi\epsilon_0} \cdot \frac{\lambda_s}{z\sqrt{(s^2/4)+z^2}}.$$

$=$