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2) Diket : Panjang batang : L
Rapat muatan linear = λ
Titik P berjarak z dari : a) ujung kawat
b) Tengah" kawat

Ditanya = a. kuat medan listrik dititik P yang berjarak z diatas ujung kawat
b. kuat medan listrik dititik P yang berjarak z diatas tengah"

Jawab :

$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r^2}$$

a. koordinat dengan kuadrat dari $x = 0$, $x = L$, dan titik P_1 berada diatas $x = 0$, sejauh z

$$r = \sqrt{x^2+z^2}$$

$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\lambda dx}{x^2+z^2} \cdot \frac{z}{\sqrt{x^2+z^2}} = \frac{1}{4\pi\varepsilon_0} \cdot \lambda z \cdot \frac{dx}{(x^2+z^2)^{3/2}}$$

Integrasi dari $x = 0$, hingga $x = L$

$$E = \frac{\lambda z}{4\pi\varepsilon_0} \int_0^L \frac{dx}{(x^2+z^2)^{3/2}}$$

$$= \int_0^L \frac{dx}{(x^2+z^2)^{3/2}} = \left[\frac{x}{z^2\sqrt{x^2+z^2}} \right]_0^L = \frac{1}{z^2\sqrt{L^2+z^2}}$$

$$E = \frac{\lambda}{4\pi\varepsilon_0} \cdot \frac{L}{z\sqrt{x^2+z^2}}$$

b) kawat dari $x = -\frac{L}{2}$, hingga $x = \frac{L}{2}$, titik P diatas titik tengahnya

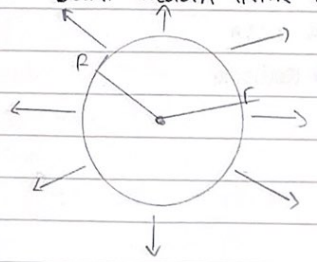
$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \lambda z \cdot \frac{dx}{(x^2+z^2)^{3/2}}$$

Integrasi dari $-\frac{L}{2}$ sampai $\frac{L}{2}$

$$E = \frac{\lambda z}{4\pi\varepsilon_0} \int_{-L/2}^{L/2} dx$$

3) Hitung medan listrik dgn rat muatan σ dan jari" R

- Besar medan listrik diluar bola ($r > R$)



$F = \frac{k q_1 q_2}{r^2}$ $\quad E = \frac{q}{4\pi\varepsilon r^2}$

$E = F/q$

$E = k \frac{q}{r^2}$

$k = \frac{1}{4\pi\varepsilon_0}$

R = jari" bola

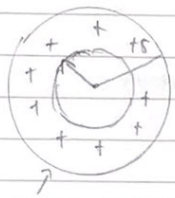
r = jari" permukaan gaus

$\varepsilon_0 = 8{,}85 \times 10^{-12}\ C^2/Nm^2$

q = total muatan listrik

- Besar medan listrik di permukaan bola ($r = R$)

$E = \frac{\sigma}{\varepsilon_0}$



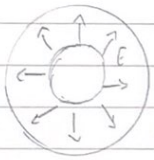
σ = Rapat permukaan

$\varepsilon_0 = 8 \times 8{,}5 \times 10^{-12}\ C^2/Nm^2$

gaussian surface

- Besar medan listrik didalam bola ($r > R$)

$E = 0$, karena muatan hanya berada dipermukaan



en (muatan dipermukaan konduktor)

4) Jawab :

2. Rapat muatan

$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$

$= \frac{1}{r^2} \frac{d}{dr} (r^2 E_r)$; $E_r = kr^3$

$r^2 E_r = r^2 \cdot kr^3 = kr^5$

$\frac{d}{dr}(kr^5) = 5kr^4$

$\nabla \cdot \vec{E} = \frac{1}{r^2} 5kr^4 = 5kr^2$

maka :

$\rho(r) = \varepsilon_0 \nabla \cdot \vec{E} = 5k\varepsilon_0 r^2$

b. muatan total

$$Q = \int_V \rho(r)\, dv$$

Pada koordinat bola, $dv = r^2 \sin\theta\, dr\, d\theta\, d\phi$

$$Q = \int_0^{2\pi}\int_0^{\pi}\int_0^{R} (5k\varepsilon_0 r^2).\, r^2 \sin\theta\, dr\, d\theta\, d\phi$$

$$= 5k\varepsilon_0 \int_0^{2\pi} d\phi \int_0^{\pi} \sin\theta\, d\theta \int_0^{R} r^4\, dr$$

$\int_0^{2\pi} d\phi = 2\pi$

$\int_0^{\pi} \sin\theta\, d\theta = 2$

$\int_0^{R} r^4\, dr = \frac{R^5}{5}$

$$= Q = 5k\varepsilon_0 \cdot 2\pi \cdot 2 \cdot \frac{R^5}{5} = 4\pi\varepsilon_0 k R^5$$

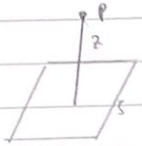
$$\rightarrow Q = 4\pi\varepsilon_0 k R^5$$

c) Medan listrik vertikal E_z yaitu :

$$E_z = \frac{2k\lambda}{z}\sin\theta \quad \text{dimana} = k = \frac{1}{4\pi\varepsilon_0}$$

λ = muatan

$\theta = \tan^{-1}\left(\frac{3/2}{z}\right)$



total medan 4 sisi

$$E_{total,z} = 4\, E_{sisi,z} = \frac{4 \cdot 2k\lambda}{z}\sin\theta = \frac{8k\lambda}{z}\sin\theta$$

dengan $\sin\theta = \frac{3/2}{\sqrt{z^2 + \left(\frac{3}{2}\right)^2}} = \frac{s}{2\sqrt{z^2 + \frac{s^2}{4}}}$

Sehingga

$$E_z = \frac{8k\lambda}{z} \cdot \frac{s}{2\sqrt{z^2 + \frac{s^2}{4}}} = \frac{4k\lambda s}{z\sqrt{z^2 + \frac{s^2}{4}}}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$E_z = \frac{\lambda s}{\pi\varepsilon_0 z\sqrt{z^2 + \frac{s^2}{4}}}$$