Date

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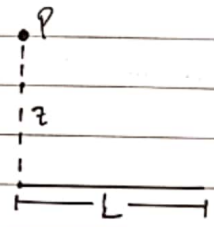
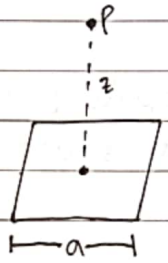
Mata Kuliah: Kelistrikan dan Kemagnetan

1. Hitung medan listrik pada salah satu ujung kawat yang panjangnya L (Gambar 2.10) yang membawa muatan seragam λ. Bagaimana besar E, jika $z >> L$.

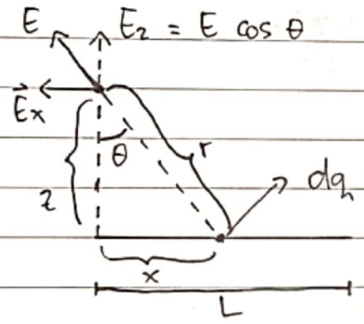


Gambar 2.10



Gambar 2.11

Penyelesaian:



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

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

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

$$\cos\theta = \frac{z}{r}$$

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

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

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

Lihat daftar integral

$$\int_0^L \frac{dx}{(z^2+x^2)^{3/2}} = \frac{1}{z^2}\frac{x}{\sqrt{z^2+x^2}}\Big|_0^L$$

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

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

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

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

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

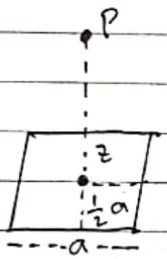
$$= -\frac{\lambda}{4\pi\epsilon_0} \left[-\left(\frac{1}{\sqrt{z^2+x^2}} - \frac{1}{z} \right) \right]$$

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

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

2. Hitung ~~muatan~~ medan listrik sejauh z dari titik tengah loop segi empat panjang yang membawa muatan seragam λ.

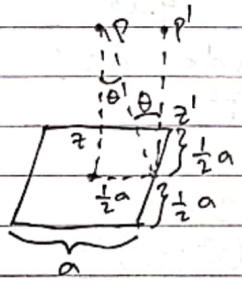
Penyelesaian:



Kawat yang panjangnya 2L, dengan $\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{2\lambda L}{z^2}$

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{2\lambda}{z'^2}$$

Konsep



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

$P = 4P' \cos\theta$;

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{2\lambda L}{z'^2} = 4 \frac{1}{4\pi\epsilon_0} \frac{2\lambda L}{z'^2} \cos\theta$$

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

maka: $\vec{E} = 4 \frac{1}{4\pi\epsilon_0} \frac{2\lambda(\frac{1}{2}a) \cdot z}{(z^2 + (\frac{1}{2}a)^2)\sqrt{z^2+(\frac{1}{2}a)^2}}$

$$\therefore \vec{E} = \frac{1}{4\pi\epsilon_0} \frac{4\lambda a z}{\left(z^2 + \frac{a^2}{4}\right)\sqrt{z^2 + \frac{a^2}{4}}}$$

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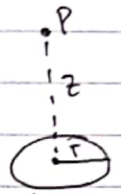
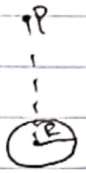
3. Hitunglah medan listrik diatas pusat kawat melingkar sejauh z yang membawa muatan seragam λ

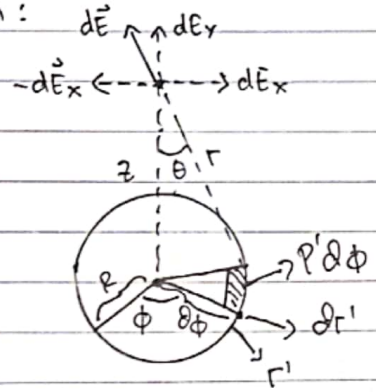


Gambar 2.12



Gambar 2.13

Pemecahan :



elemen luar

$\rightarrow$ ds = da = P x l

= dr' . r'∂ϕ

da = r' dr' dϕ