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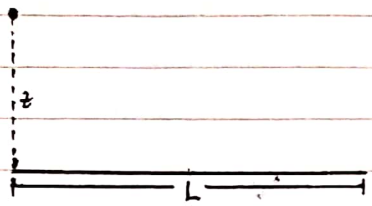
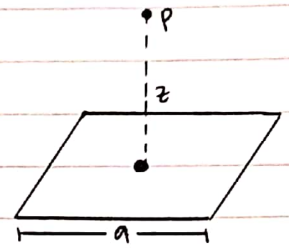
1. Hitung medan listrik pada salah satu ujung kawat yang panjangnya L (Gambar 2.10) yang membawa muatan seragam λ. Bagaimana besar E, jika $z \gg L$

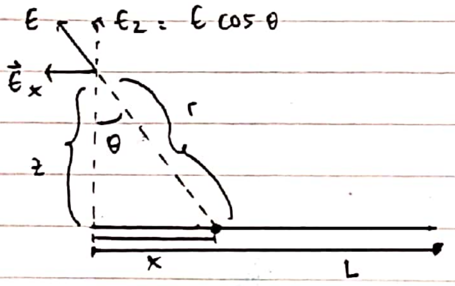


Gambar 2.10



Gambar 2.4

Penyelesaian:



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

Ambil $\vec{E}_z = \boxed{\dfrac{1}{4\pi\varepsilon_0}\displaystyle\int_0^L \dfrac{dq}{r^2} = \dfrac{1}{\square}\displaystyle\int_0^L \dfrac{\lambda\, dx}{r^2} \quad \cos\theta}$, dimana $\cos\theta = \dfrac{z}{r}$

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

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

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

$$= \frac{1}{4\pi\varepsilon_0}\lambda z\left[\frac{1}{z^2}\frac{x}{\sqrt{z^2+x^2}}\right|_0^2$$

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

$$\vec{E}_x = -\frac{1}{4\pi\varepsilon_0}\int_0^L \frac{\lambda dx}{p^2}\sin\theta = \frac{\lambda}{4\pi\varepsilon_0}\int_0^L \frac{x\, dx}{(z^2+x^2)^{3/2}}$$

arah $\vec{E}_x$ kekiri $= -\dfrac{\lambda}{4\pi\varepsilon_0}\cdot\dfrac{1}{2}\displaystyle\int_0^L \dfrac{dx^2}{(z^2+x^2)^{3/2}}$

$$= -\frac{\lambda}{4\pi\varepsilon_0}\cdot\frac{1}{2}\cdot\left[-2\frac{1}{(z^2+x^2)^{1/2}}\right|_0^2$$

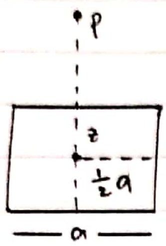
Dipindai dengan CamScanner

$$= -\frac{\lambda}{4\pi\varepsilon_0}\left[-\left(\frac{1}{\sqrt{z^2+x^2}} - \frac{1}{z}\right)\right]$$

$$\vec{E}_x = -\frac{\lambda}{4\pi\varepsilon_0}\left[\frac{1}{z} - \frac{1}{\sqrt{z^2+x^2}}\right]$$

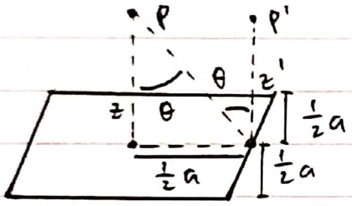
Jadi $\boxed{\vec{E} = \vec{E}_z + \vec{E}_x}$

2\.



Solusi : untuk menyelesaikan soal tersebut gunakan contoh no. 2 yaitu kawat yang panjangnya 2L, dengan $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z^2}$

Maka $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z^2}$ Hasil contoh :



P = P' cos θ, karena ada 4 sisi, maka :

P = 4P' cos θ, sehingga.

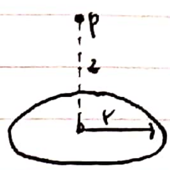
$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z'^2}} = 4 \cdot \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z'^2}\cos\theta$$

karena $L = \frac{1}{2}a$, dan $z' = r\sqrt{z^2+(\frac{1}{2})^2}$, dan $\cos\theta = \frac{z}{\sqrt{z^2+(\frac{1}{2})^2 a}}$, maka.

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

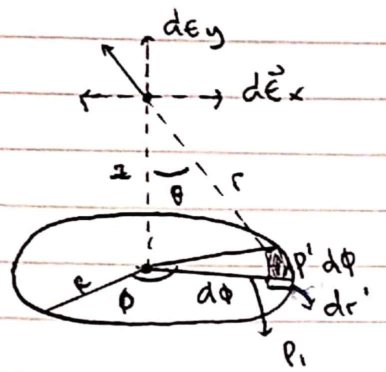
$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{4\lambda a z}{\left(z^2+\frac{a^2}{a}\right)\sqrt{z^2+\frac{a^2}{4}}}$$

3\. Hitung medan listrik di atas pusat kawat melingkar sejauh z yang membawa muatan seragam (Gambar 2.12)



Gambar 2.12.

Penyelesaian



elemen luas

$ds = da = p \times l$

$= dr' \cdot p' d\phi$

$da = r'\, dr'\, d\phi$

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

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

$= dE \cos\theta$

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} \int_0^R \int_0^{2\pi} \frac{\sigma}{r^2} \cos\theta \cdot r'\, dr'\, d\phi}$$

Tukar $\cos\theta$ dengan P^2, sehingga menjadi :

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

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

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