$P = P' \cos\theta$, karena ... , Maka

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

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Prodi : Pendidikan fisika (B)

$\Rightarrow$ Medan listrik Oleh Muatan terdistribusi

Analog dari Medan listrik Oleh Muatan titik

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{p^2} \hat{P}_0$$

Maka Medan listrik oleh muatan kontinue/terdistribusi dapat dihitung dengan 2 fasa, Yaitu :

a) Hukum Colomb

Hukum Colomb dalam Penerapannya, Menggunakan Integral dalam sistem koordinat kartesian, bola dan silinder.

1.) Untuk Integral garis

$$\vec{E} = \int \frac{1}{4\pi\varepsilon_0} \frac{dq}{r^2} \hat{r}_0 \Rightarrow \text{dengan } dq = \lambda\, dl \text{ atau } \lambda dp$$

Sehingga

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda\, dl}{r^2} \hat{r}_0$$

2.) Untuk luas permukaan

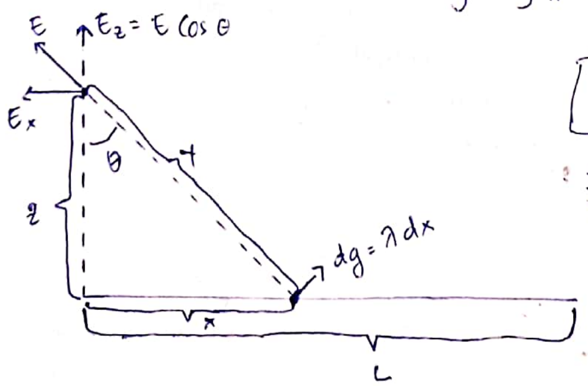
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \iint \frac{\sigma\, d\vec{s}}{r^2} \hat{r}_0$$

3.) Untuk Volume

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \iiint \frac{\rho\, d\tau}{r^2} \hat{r}_0$$

Contoh Penerapan hukum Columb Untuk Menghitung Medan listrik

1)



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

$$\vec{E}_z = \frac{1}{4\pi\varepsilon_0} \int_0^L d\vec{E} \cos\theta$$

Dipindai dengan CamScanner

Ambil $\vec{E}_z = \frac{1}{4\pi\varepsilon_0}\int_0^L \frac{dq}{r^2} = \frac{1}{\Box}\int_0^L \frac{\lambda dx}{r^2}\cos\theta$

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

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

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

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

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

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

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

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

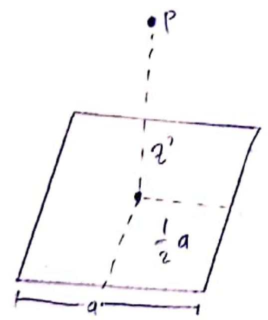
$= -\frac{\lambda}{4\pi\varepsilon_0}\cdot\frac{1}{2}\left[-2\frac{1}{(z^2+x^2)^{1/2}}\right|_0^L$

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

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

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

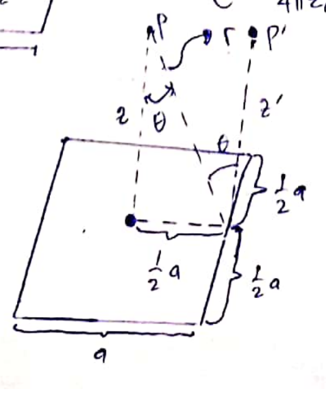
2)



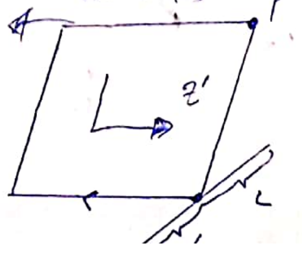
Solusi : Untuk Menyelesaikan hal tersebut. gunakan Contoh no 3, yaitu kawat yang panjangnya $2L$, dengan $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z'^2}$

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z'^2}$ Hasil Contoh no 3

Konsep



Contoh No 3



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

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

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

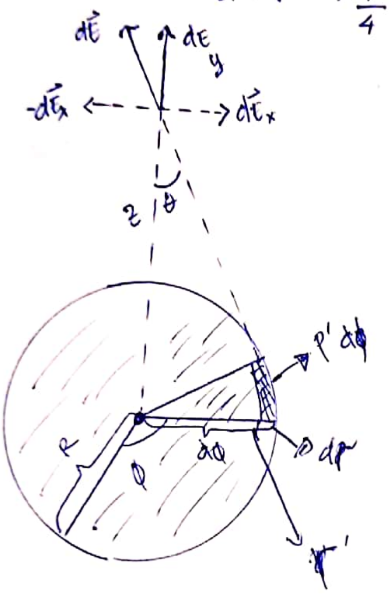
karena $L = \frac{1}{2}a$, dan $z' = r = \sqrt{z^2+(\frac{1}{2}a)^2}$

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

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

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

3.)



elemen luas

$\Rightarrow ds = da = P \times l$

$= dP' . P'd\phi$

$da = P' dr' d\phi$