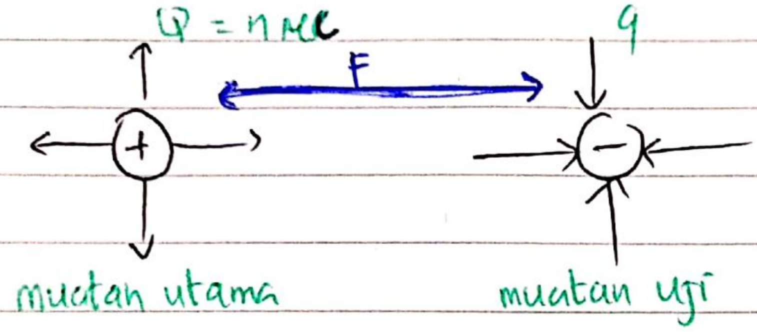
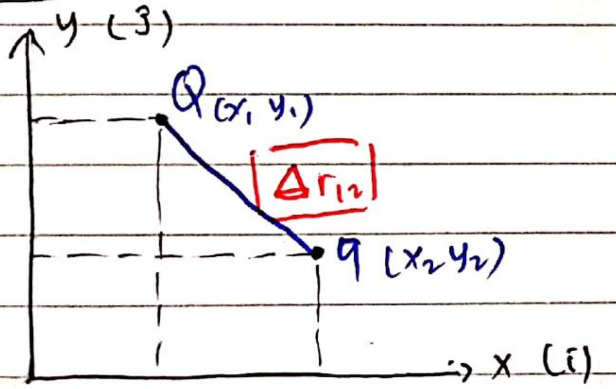
Kamis, 25 April 2024

- Medan Listrik



- muatan uji dipengaruhi oleh muatan utama.,
- muatan utama mempengaruhi muatan uji .
- listrik dua dimensi .

example:



$$\hat{r}_{Qq} = \frac{\Delta x \hat{i} + \Delta y \hat{j}}{\sqrt{\Delta x^2 + \Delta y^2}} = \frac{\vec{r}_{Qq}}{|\vec{r}_{Qq}|}$$

$$\downarrow$$

$$|\hat{r}_{Qq}| = r_{Qq} = \sqrt{\Delta x^2 + \Delta y^2}$$

$$F_{Qq} = q \cdot E_Q$$

$$F_{Qq} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \cdot q}{r^2_{Qq}} \hat{r}_{Qq}$$

$$\cancel{q}\, E_Q = \frac{1}{4\pi\varepsilon_0} \frac{Q \cancel{q}}{r^2_{Qq}} \cdot \hat{r}_{Qq}$$

$$\boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2_{Qq}} \hat{r}_{Qq}} \longrightarrow \boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^3_{Qq}} \vec{r}_{Qq}}$$

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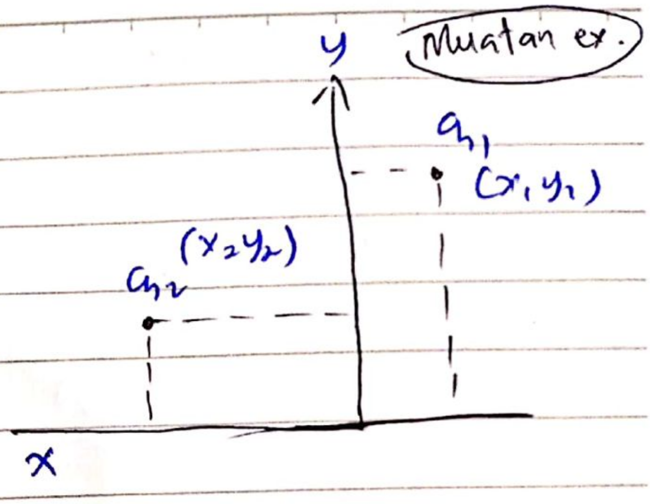
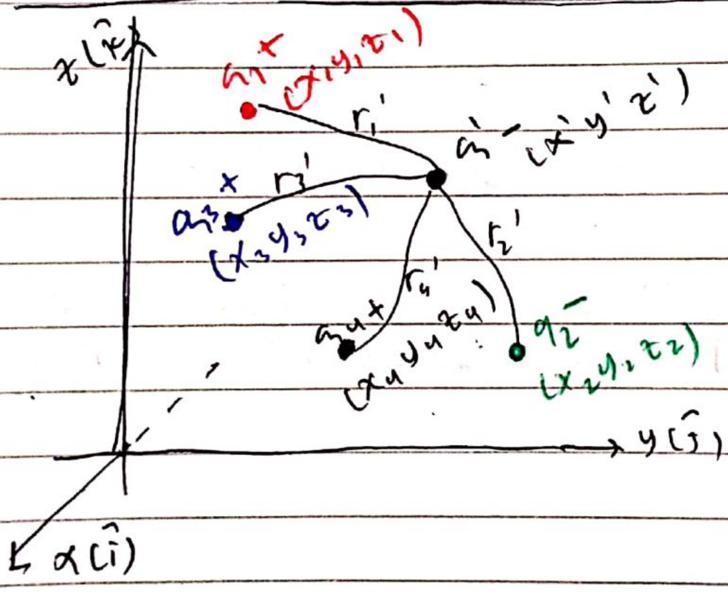
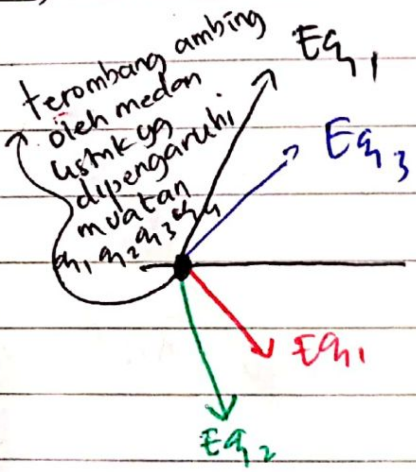
$$\boxed{\vec{E}_{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{12}^2}\cdot\hat{r}_{12}}$$

$$\boxed{E_{q_2} = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_{21}^2}\hat{r}_{21}}$$



• Medan Listrik yg dihasilkan oleh banyak Muatan.





$$\boxed{q_1 < q_2 < q_3 < q_4}$$

$$\boxed{E_{total} = E_{q'} = E_{q_1} + E_{q_2} + E_{q_3} + E_{q_4}}$$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_1'^2}\hat{r}_1'$$

$$E_{q_2} = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_2'^2}\hat{r}_2'$$

$$E_{q_3} = \frac{1}{4\pi\varepsilon_0}\frac{q_3}{r_3'^2}\hat{r}_3'$$

$$E_{q_4} = \frac{1}{4\pi\varepsilon_0}\frac{q_4}{r_4'^2}\hat{r}_4'$$

$$\hat{r}_{1'} = \frac{\vec{r}_{1'}}{|\vec{r}_{1'}|} = \frac{\Delta x_{1'}\,\hat{i} + \Delta y_{1'}\,\hat{j} + \Delta z_{1'}\,\hat{k}}{\sqrt{\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2}}$$

$$\vec{r}_{1'} = \underset{\downarrow\;(x'-x_1)}{\Delta x_{1'}}\,\hat{i} + \underset{\downarrow\;(y'-y_1)}{\Delta y_{1'}}\,\hat{j} + \underset{\downarrow\;(z'-z_1)}{\Delta z_{1'}}\,\hat{k}$$

$$r_{1'} = |\vec{r}_{1'}| = (\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{1/2}$$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{1'}^2}\,\hat{r}_{1'}$$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{\left[(\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}\right]^2} \cdot \frac{\Delta x_{1'}\,\hat{i} + \Delta y_{1'}\,\hat{j} + \Delta z_{1'}\,\hat{k}}{(\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}}$$

$$\boxed{E_{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{(\Delta x_{1'}^2 + \Delta x_{1'}^2 + \Delta z_{1'}^2)(\Delta x_{1'}^2 + \Delta x_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}}(\Delta x_{1'}\,\hat{i} + \Delta y_{1'}\,\hat{j} + \Delta z_{1'}\,\hat{k})}$$

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Medan Listrik yg dihasilkan distribusi Muatan.

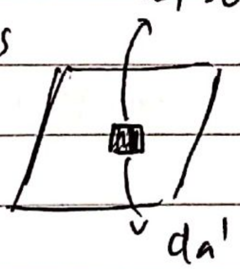
Tabel. Diferensial unsur panjang, luas, dan Volume pada koordinat yang berbeda.

	Kartesius (x,y,z)	Silinder (ρ, ϕ, z)	Bola (r, θ, ϕ)
dl	dx, dy, dz	$d\rho, \rho d\phi, dz$	$dr, r d\theta, r\sin\theta d\phi$
dA	$dxdy, dydz, dzdx$	$d\rho dz, \rho d\phi dz, \rho d\phi d\rho$	$rdrd\theta, r\sin\theta dr d\phi, r^2\sin\theta d\theta d\phi$
dV	$dxdydz$	$\rho d\rho d\phi dz$	$r^2 \sin\theta dr d\theta d\phi$

Rapat Muatan : kuantitas muatan yg terdistribusi pd garis / bidang / ruang tertentu.

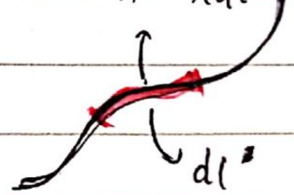
- Rapat Muatan luas

$$\sigma = \frac{\partial q'}{\partial A'}$$



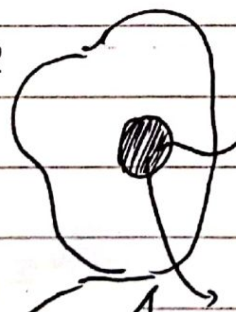
- Rapat Muatan panjang

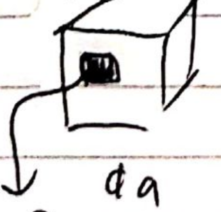
$$\lambda = \frac{\partial q'}{\partial l'} = \frac{dq'}{ds'}$$



- Rapat Muatan Volume

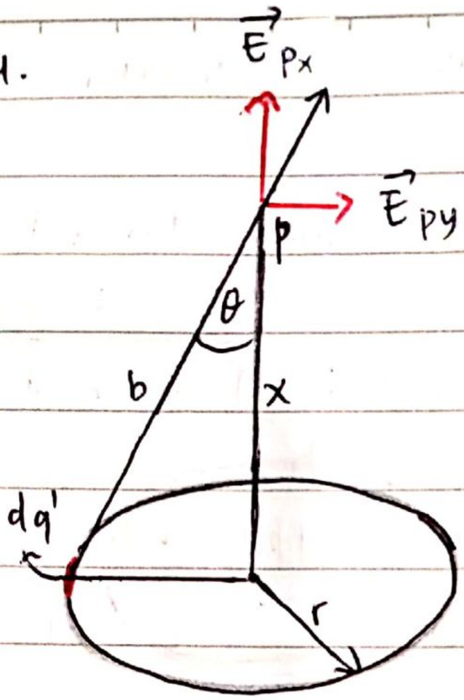
$$\rho = \frac{\partial q'}{\partial V'}$$





$$\rho = \frac{dq}{dv} \rightarrow (dxdy, dz)$$

• Medan listrik disumbu.



Keliling lingkaran :

$$\lambda = \frac{dq'}{2\pi r}$$

Kerapatan muatan cincin (muatan per satuan panjang).

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$$\boxed{E_{total} = E_{q'} = E_{q_1} + E_{q_2} + E_{q_3} + E_{q_4}}$$

$$* \; E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_1'^2} \hat{r}_1'$$

$$\hat{r}_1 = \frac{\vec{r}_1}{|r_1'|} = \frac{\Delta x_1' \hat{i} + \Delta y_1' \hat{j} + \Delta z_1' \hat{k}}{\sqrt{\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2}}$$

$$* \; E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_2}{r_2'^2} \hat{r}_2'$$

$$r_1' = |\vec{r}_1'| = \left(\underbrace{\Delta x_1'^2}_{(x'-x_1)} + \underbrace{\Delta y_1'^2}_{(y'-y_1)} + \underbrace{\Delta z_1'^2}_{(z'-z_1)}\right)^{\frac{1}{2}}$$

$$* \; E_{q_3} = \frac{1}{4\pi\varepsilon_0} \frac{q_3}{r_3'^2} \hat{r}_3'$$

$$* \; E_{q_4} = \frac{1}{4\pi\varepsilon_0} \frac{q_4}{r_4'} \hat{r}_4'$$

Sehingga menjadi :

$$* \; E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_1'^2} \hat{r}_1'$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_1}{\left((\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}\right)^2} \cdot \frac{\Delta x_1' \hat{i} + \Delta y_1' \hat{j} + \Delta z_1' \hat{k}}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}} \cdot \Delta x_1' \hat{i} + \Delta y_1' \hat{j} + \Delta z_1' \hat{k}$$

$$* \; E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_2'^2} \hat{r}_2'$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_2}{\left((\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}\right)^2} \frac{\Delta x_2' \hat{i} + \Delta y_2' \hat{j} + \Delta z_2' \hat{k}}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_2}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}} \cdot \Delta x_2' \hat{i} + \Delta y_2' \hat{j} + \Delta z_2' \hat{k}$$

$$* \; E_{q_3} = \frac{1}{4\pi\varepsilon_0} \frac{q_3}{r_3'^2} \hat{r}_3 .$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_3}{\left((\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}\right)^2} \cdot \frac{\Delta x_3' \hat{i} + \Delta y_3' \hat{j} + \Delta z_3' \hat{k}}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{1/2}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_3}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}} \cdot \Delta x_3' \hat{i} + \Delta y_3' \hat{j} + \Delta z_3' \hat{k}$$

$$* \; E_{q_4} = \frac{1}{4\pi\varepsilon_0} \frac{q_4}{r_4'^2} \hat{r}_4$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_4}{\left((\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}\right)^2} \cdot \frac{\Delta x_4' \hat{i} + \Delta y_4' \hat{j} + \Delta z_4' \hat{k}}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{1/2}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_4}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}} \cdot \Delta x_4' \hat{i} + \Delta y_4' \hat{j} + \Delta z_4' \hat{k}$$

$$E_{total} = E_{q'} = E_{q_1} + E_{q_2} + E_{q_3} + E_{q_4} .$$

$$E_{q'} = \left(\frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}} (\Delta x_1' \hat{i} + \Delta y_1' \hat{j} + \Delta z_1' \hat{k}) \right)$$

$$+ \left(\frac{1}{4\pi\varepsilon_0} \frac{q_2}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}} (\Delta x_2' \hat{i} + \Delta y_2' \hat{j} + \Delta z_2' \hat{k}) \right)$$

$$+ \left(\frac{1}{4\pi\varepsilon_0} \frac{q_3}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}} (\Delta x_3' \hat{i} + \Delta y_3' \hat{j} + \Delta z_3' \hat{k}) \right)$$

$$+ \left(\frac{1}{4\pi\varepsilon_0} \frac{q_4}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}} (\Delta x_4' \hat{i} + \Delta y_4' \hat{j} + \Delta z_4' \hat{k}) \right)$$

$$E_{q'} = \frac{1}{4\pi\varepsilon_0} \left(\frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}} (\Delta x_1' \hat{i} + \Delta y_1' \hat{j} + \Delta z_1' \hat{k}) + \right.$$

$$\left(\frac{q_2}{(\Delta x_2'^2+\Delta y_2'^2+\Delta z_2'^2)(\Delta x_2'^2+\Delta y_2'^2+\Delta z_2'^2)^{\frac{1}{2}}}\left(\Delta x_2'\hat{i}+\Delta y_2'\hat{j}+\Delta z_2'\hat{k}\right)\right)+$$

$$\left(\frac{q_3}{(\Delta x_3'^2+\Delta y_3'^2+\Delta z_3'^2)(\Delta x_3'^2+\Delta y_3'^2+\Delta z_3'^2)^{\frac{1}{2}}}\left(\Delta x_3'\hat{i}+\Delta y_3'\hat{j}+\Delta z_3'\hat{k}\right)\right)+$$

$$\left(\frac{q_4}{(\Delta x_4'^2+\Delta y_4'^2+\Delta z_4'^2)(\Delta x_4'^2+\Delta y_4'^2+\Delta z_4'^2)^{\frac{1}{2}}}\left(\Delta x_4'\hat{i}+\Delta y_4'\hat{j}+\Delta z_4'\hat{k}\right)\right)$$

Kamis, 2 Mei 2024.

$\lambda = \frac{q}{l}$ → keliling

$ds' = \frac{s}{N}$ → $L = 2\pi r$

$\partial L = 2\pi \partial r$

$\lambda = \frac{q}{k}$

$ds' = 2\pi dr$

$\boxed{\lambda = \frac{q}{2\pi r}}$ $\boxed{\lambda = \frac{q}{L}}$ penuh

Sebagian $\boxed{\lambda = \frac{\partial q}{\partial L}}$ → $\boxed{\partial q = \lambda \cdot \partial L}$

Medan listrik:

$$\boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}}$$

$$\boxed{E_{\partial q} = \frac{1}{4\pi\varepsilon_0} \frac{\partial q}{b^2}}$$

$$E_{\partial q} = \frac{1}{4\pi\varepsilon_0} \frac{\lambda \partial l}{(r^2 + x^2)}$$

$$\boxed{\sin\theta = \frac{r}{(r^2 + x^2)^{\frac{1}{2}}}}$$

$$E_{\partial q y} = E_{\partial q} \cdot \sin\theta = \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda \partial l}{(r^2 + x^2)} \sin\theta$$

$$= \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda \partial l}{(r^2 + x^2)} \cdot \frac{r}{(r^2 + x^2)^{\frac{1}{2}}}$$

$$\boxed{\cos\theta = \frac{x}{(r^2 + x^2)^{\frac{1}{2}}}}$$

$$E_{dq_x} = E_{dx} \cdot \cos\theta = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dl}{(r^2+x^2)} \cos\theta$$

$$\vec{E_p} = \vec{E_{p_x}} = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dl}{(r^2+x^2)} \cdot \frac{x}{(r^2+x^2)^{\frac{1}{2}}}$$

$$\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{\frac{3}{2}}} \int dl'$$

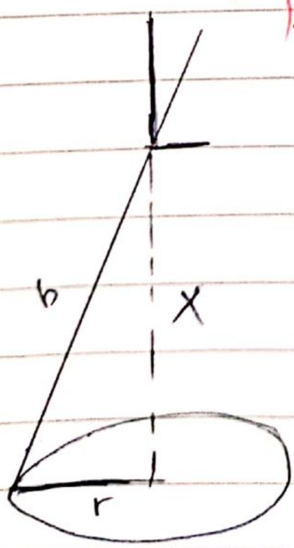
$$\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{\frac{3}{2}}} \int 2\pi\, dr$$

$$\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{\frac{3}{2}}}\, 2\pi \int dr$$

$$\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{\frac{3}{2}}}\, 2\pi \left[r \right]_0^r$$

$$\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{(\lambda 2\pi r)\, x}{(r^2+x^2)^{\frac{3}{2}}}$$

$$\boxed{\vec{E_p} = \frac{1}{4\pi\varepsilon_0} \frac{q x}{(r^2+x^2)^{\frac{3}{2}}}}$$



Diketahui :

$q = \lambda \cdot 2\pi r$.

$r = 3$ cm

$x = 4$ cm

$b = 5$ cm

$Q = 14$ nC

$E_p = ?$

$\overline{r} = \quad b$

$\sin^2\theta = \dfrac{r^2}{b^2}$ | $\sin\theta^2$ → cari $\sin\theta$ nya lalu dikuadratkan.

$$\vec{E}_{px} = \frac{1}{4\pi\varepsilon_0}\frac{qx}{\left(\left\{r^2+x^2\right\}^{\frac{1}{2}}\right)^3}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{qx}{b^3}$$

$$= \frac{1}{4\pi\varepsilon_0} q \frac{1}{b^2}\frac{x}{b}$$

$$= \frac{1}{4\pi\varepsilon_0} q \frac{1}{b^2}\frac{x}{b}\frac{r^2}{r^2}$$

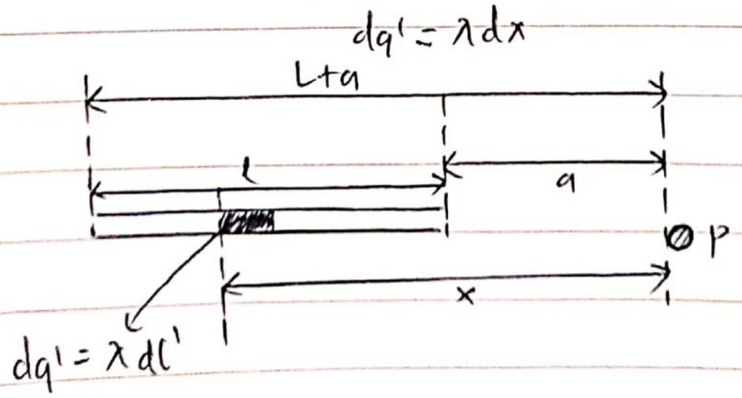
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{r^2}{b^2}\frac{x}{b}$$

Karena nilai $\frac{r}{b} = \sin\theta$, $\frac{x}{b} = \cos\theta$ maka, ..

$$\vec{E}_{px} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{r^2}{b^2}\frac{x}{b}$$

$$\boxed{\vec{E}_{px} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\sin^2\theta\cos\theta}$$

- Medan Listrik oleh Muatan Batang



$$\vec{E}_p = k \int \frac{dq'}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda dl'}{x^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \int_a^{l+a} \frac{dx}{x^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \int_a^{l+a} \left(\frac{1}{x^2}\right) dx$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left[-\frac{1}{x}\right]_a^{l+a}$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left[\left\{-\frac{1}{l+a}\right\} - \left\{-\frac{1}{a}\right\}\right]$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left[\left\{\frac{1}{a}\right\} - \left\{\frac{1}{l+a}\right\}\right]$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left[\left\{\frac{l+a}{a(l+a)}\right\} - \left\{\frac{a \cdot}{a(l+a)}\right\}\right]$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left\{\frac{(l+a)-a}{a(l+a)}\right\}$$

$$= \frac{1}{4\pi\varepsilon_0} \lambda \left[\frac{l}{a(l+a)}\right\}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\lambda l}{(al+a^2)}$$

$$= \boxed{\frac{1}{4\pi\varepsilon_0} \frac{q}{(al+a^2)}}$$

$$= \int \left(\frac{1}{x^2}\right) \partial x$$

$$= \int (x^{-2}) \partial x$$

$$= \left(-2+1 \cdot x^{-2+1}\right)$$

$$= \left(-1 \cdot x^{-1}\right)_a^{l+a}$$

$$= \left(-\frac{1}{x}\right)_a^{l+a}$$