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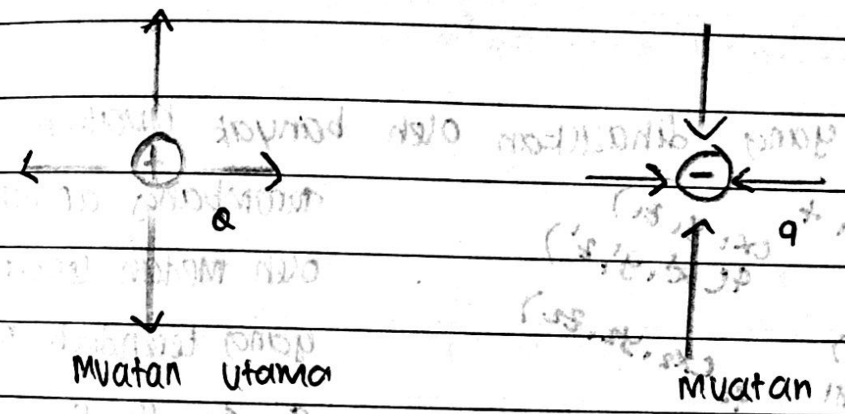
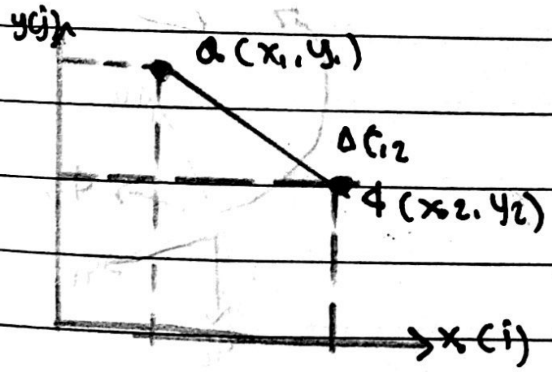
KALISMA

MEDAN LISTRIK

area atau daerah sebuah muatan yang didekatkan masih terpengaruhi oleh gaya coulomb (listrik)





$\vec{F}_{21} = Q_2 \cdot \vec{E}_{21}$

$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{r_{21}^2} \hat{r}_{21}$

$\vec{E}_{21} = Q_1 \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{r_{21}^2} \hat{r}_{21}$

$$\boxed{\vec{E}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{r_{21}^2} \hat{r}_{21}}$$

$\hat{r}_{21} = \frac{\Delta x \hat{i} + \Delta y \hat{j}}{\sqrt{\Delta x^2 + \Delta y^2}} = \frac{\vec{r}_{21}}{|\hat{r}_{21}|}$

$|\hat{r}_{21}| = r_{21} = \sqrt{\Delta x^2 + \Delta y^2}$

$\vec{E}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{Q_1}{r_{21}^3} \hat{r}_{21}$

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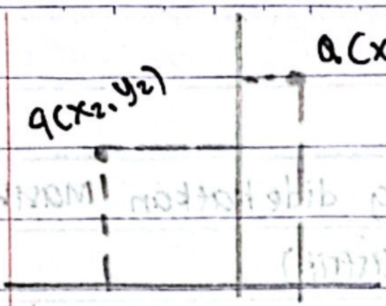
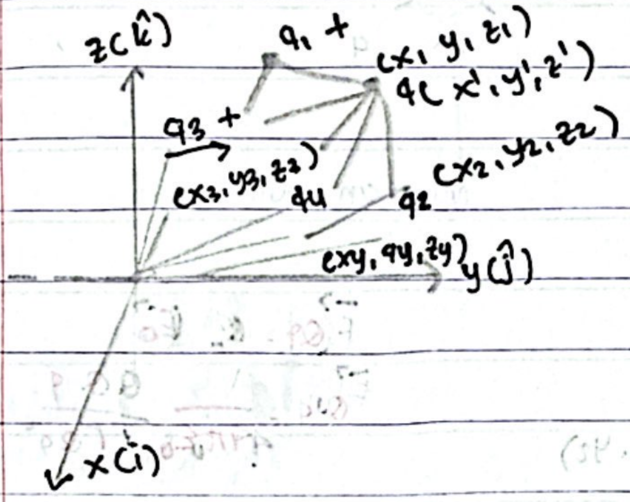


$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_{12}^2} \hat{r}_{12}$$

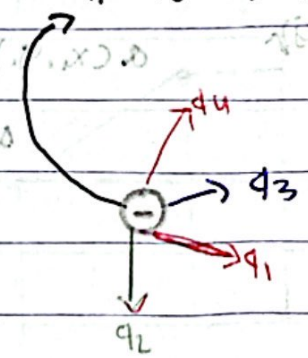
$$E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_2}{r_{21}^2} \hat{r}_{21}$$

- Medan listrik yang dihasilkan oleh banyak muatan



terombang ambing oleh medan listrik yang terendah maka

$q_1 \; q_2 \; q_3 \; q_4$



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

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

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

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

$$q_1 < q_2 < q_3 < q_4$$

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

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

$$\vec{r}_1' = \Delta x_1 \hat{i} + \Delta y_1 \hat{j} + \Delta z_1 \hat{k}$$

$$(x' - x_1) \; (y' - y_1) \; (z' - z_1)$$

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

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{\left((\Delta x_i^2 + \Delta y_i^2 + \Delta z_i^2)^{1/2}\right)^2} = \frac{\Delta x_i \hat{i} + \Delta y_i' \hat{j} + \Delta z_i \hat{k}}{(\Delta x_i^2 + \Delta y_i^2 + \Delta z_i^2)^{1/2}}$$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_i^2 + \Delta y_i'^2 + \Delta z_i^2)(\Delta x_i^2 + \Delta y_i'^2 + \Delta z_i^2)^{1/2}} \cdot \Delta x_i \hat{i} + \Delta y_i \hat{j} + \Delta z_i \hat{k}$$

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

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

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

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

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

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

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

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

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

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$$E_{total} = E_{q1} = E_{q1} + E_{q2} + E_{q3} + E_{q4}$$

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

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

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

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

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⇒ medan listrik yang dihasilkan distribusi muatan

	cartesian (x, y, z)	cylindrical (ρ, ϕ, z)	spherical (r, θ, ϕ)
dl	dx, dy, dz	$d\rho, \rho d\phi, dz$	dr $r d\theta$ $r \sin\theta$ $d\phi$
dA	$dx\,dy, dy\,dz, dz\,dx$	$d\rho\,dt, \rho\, d\phi\, dz, \rho\, d\phi\, d\rho$	$r\, dr\, d\theta, r \sin\theta\, dr\, d\theta,$
...			$r^2 \sin\theta\, d\theta\, d\phi$
dv	dx, dy, dz	$\rho d, \rho\, d\phi\, dz$	$r^2 \sin\theta\, dr\, d\theta\, d\phi$

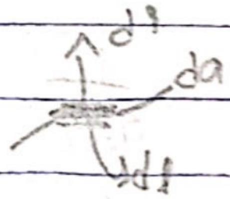
ket dl = panjang
dA = luas
dv = volume

Rapat muatan = suatu muatan listrik yang terdistribusi dalam suatu bidang tertentu dan ruang tertentu

example

1) rapat muatan panjang (ds') atau (dl')

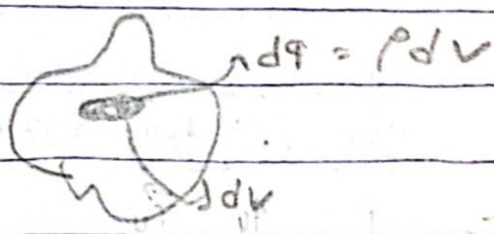
$$\lambda = \frac{dq'}{dl} \quad \text{atau} \quad \lambda = \frac{dq}{dl}$$



2. Rapat muatan volume (dr') atau (dv')

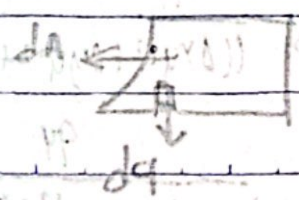
$$\rho = \frac{dq}{dv}$$

$$\rho = \frac{dr}{dq}$$



3. Rapat muatan luas (da')

$$\sigma = \frac{dq}{dA}$$



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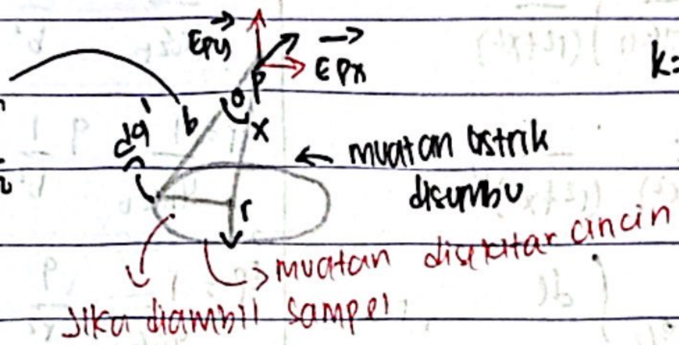
•) medan listrik oleh muatan cincin



jarak

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

$k = 2\pi r$

$dl = 2\pi \gamma r$

$ds' = 2\pi \gamma r$

$\sin\theta = \dfrac{r}{(r^2+x^2)^{1/2}}$ $\cos\theta = \dfrac{x}{(r^2+x^2)^{1/2}}$

kecepatan muatan cincin (muatan per satuan panjang)

$\lambda = \dfrac{q}{l}$ $\rightarrow \lambda = \dfrac{q}{k}$

$\lambda = \dfrac{dq'}{2\pi r}$ $\rightarrow$ kel ungkaran

$E\,dq = \dfrac{1}{4\pi\varepsilon_0}\dfrac{\partial q}{b^2}$

$\lambda = \dfrac{\partial q}{\partial l}$

$\lambda = \dfrac{q}{L}$

$E\partial d = \dfrac{1}{4\pi\varepsilon_0}\dfrac{\lambda \partial L}{r^2+x^2}$

$\lambda = \dfrac{q}{2\pi r}$ $\partial q = \lambda\, dL$

$q = \lambda\, 2\pi r$

$\vec{E}\partial qy = E\partial q \sin\theta = \dfrac{1}{4\pi\varepsilon_0}\displaystyle\int \dfrac{\lambda\,\partial l}{(r^2+x^2)} \sin\theta$

$= \dfrac{1}{4\pi\varepsilon_0}\displaystyle\int \dfrac{\lambda.\partial l}{(r^2+x^2)}\dfrac{r}{(r^2+x^2)^{1/2}}$

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$$\vec{E}\,\partial qx = E\partial q\cos\theta = \frac{1}{4\pi\varepsilon_0}\int\frac{\lambda\,\partial l}{(r^2+x^2)}\cos\theta$$

$$\vec{E}px = \frac{1}{4\pi\varepsilon_0}\int\frac{\lambda\partial l}{(r^2+x^2)}\;\frac{x}{(r^2+x^2)^{1/2}}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{\lambda x}{(r^2+x^2)^{3/2}}\int dl$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{\lambda x}{(r^2+x^2)^{3/2}}\int_0^r 2\pi\partial r$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{\lambda}{(r^2+x^2)^{3/2}}\;2\pi\Big|_0^r\partial r$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{\lambda}{(r^2+x^2)^{3/2}}\;2\pi(r)_0^r$$

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

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{qx}{(r^2+x^2)^{3/2}}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{qx}{(r^2+x^2)^{3/2}}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{qx}{((r^2+x^2)^{1/2})^3}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{qx}{b^3}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;q\;\frac{1}{b^2}\;\frac{x}{b}$$

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

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{q}{r^2}\;\frac{r^2}{b^2}\;\frac{x}{b} \rightarrow \sin\theta = \frac{r}{b}$$

$$\sin^2\theta = \frac{r^2}{b^2}$$

$$\vec{E}p = \frac{1}{4\pi\varepsilon_0}\;\frac{q}{r^2}\sin^2\theta\cos\theta$$

$$\cos\theta = \frac{x}{b}$$

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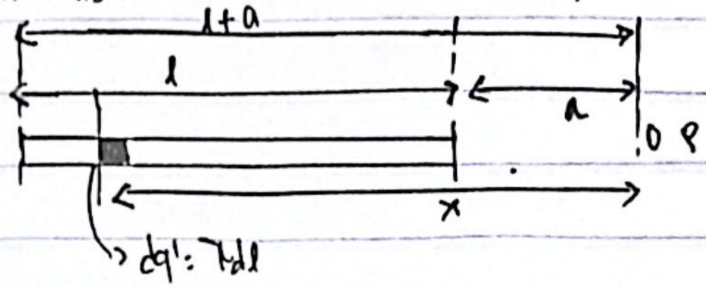
Medan listrik oleh muatan Batang



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

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

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

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

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

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

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

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

$\vec{E}p = \frac{1}{4\pi\varepsilon_0} \lambda \left\{\frac{l}{a\{l+a\}}\right\}$

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

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