Kalisma Listrik Statis

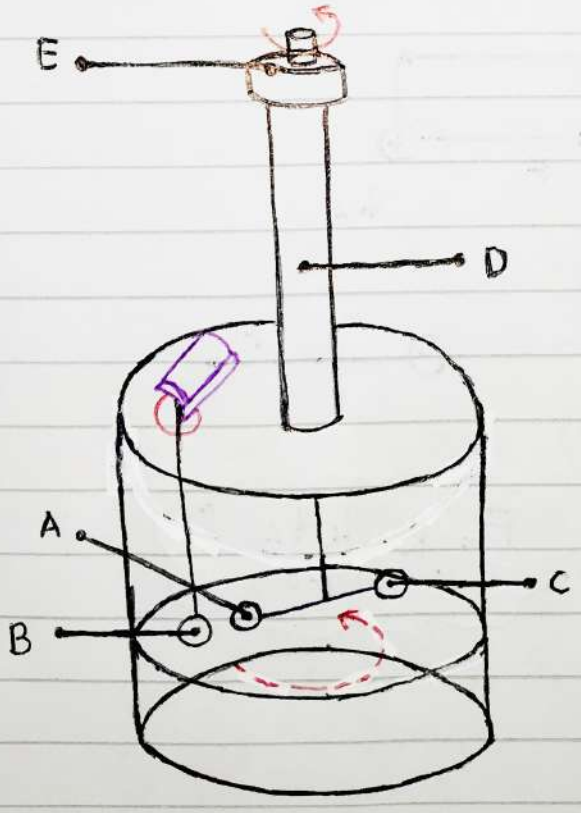
Gaya Listrik

Hukum Coulomb

- Gaya yg dilakukan oleh satu muatan titik pada muatan titik lainnya bekerja sepanjang garis yang menghubungkan kedua muatan tersebut. Besarnya gaya berbanding terbalik kuadrat jarak keduanya, berbanding lurus dengan perkalian kedua muatan.
- Gaya tolak menolak → muatan sama
- Gaya tarik menarik → muatan beda

$$F_{12} = \frac{kq_1 q_2}{r_{12}^2} \hat{r}_{12}$$

- Dengan $k = 8.99\ 10^9\ N.m^2/C^2$



No.

Date

LISTRIK STATIS

↳ Suatu fenomena listrik yang ditimbulkan ketika partikel bermuatan di transfer dari satu benda ke benda lain, hal ini terjadi karena adanya dua buah benda yang saling bergesekan.

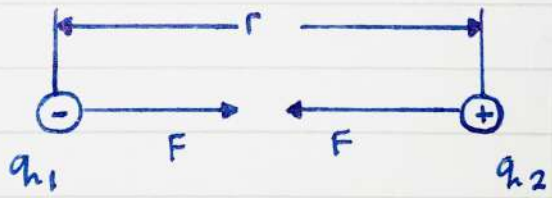
→ MUATAN LISTRIK

↳ Atom terdiri dari dua bagian, yakni inti atom dan kulit atom.

- Inti atom : proton (+) & neutron (netral)
- Kulit atom : elektron (-)

1. GAYA COULOMB

↳ Besarnya gaya listrik yang terjadi antara dua benda yang bermuatan dengan jarak benda / yang memiliki jarak.



$$F = k \frac{q_1 q_2}{r^2}$$

$$F = k \frac{q_1 q_2}{r^2} \hat{r}$$

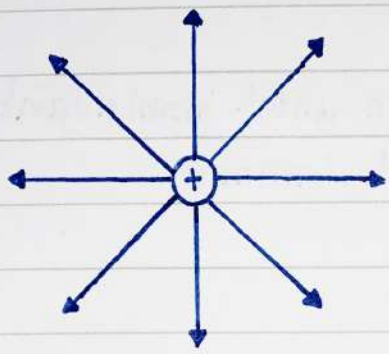
$$k = 9 \times 10^9 \ Nm^2 / c^2$$

No.

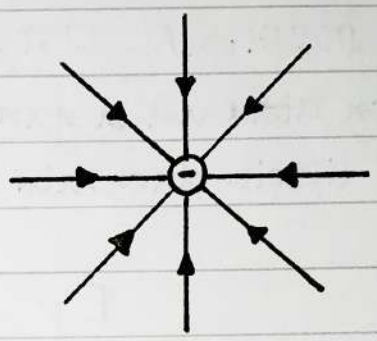
Date . .

2. MEDAN LISTRIK

↳ Daerah disekitar partikel bermuatan listrik yang masih dipengaruhi gaya listrik (gaya Coulomb).



Muatan Positif



Muatan Negatif

- Benda bermuatan yang menghasilkan medan listrik disebut muatan sumber. Sedangkan, muatan lain yang di-letakkan dalam pengaruh medan listrik muatan sumber disebut sebagai muatan uji.

$$E = k\frac{Q}{r^2} \quad \text{atau} \quad E = \frac{F}{q}$$

Keterangan :

E = kuat medan listrik (N/C)

Q = besar muatan sumber (C)

q = besar muatan uji (C)

F = Gaya Coulomb

3. POTENSIAL LISTRIK

Usaha per satuan muatan yang dibutuhkan untuk memindahkan satu muatan dari satu titik ke titik lainnya.

No.

Date

$$V = k \frac{Q}{r}$$

V = potensial listrik

4. ENERGI POTENSIAL LISTRIK

Energi atau usaha yang dibutuhkan untuk memindahkan muatan listrik dari satu titik ke titik lainnya.

$$Ep = k \frac{q_1 q_2}{r}$$

No. Kamis (6)

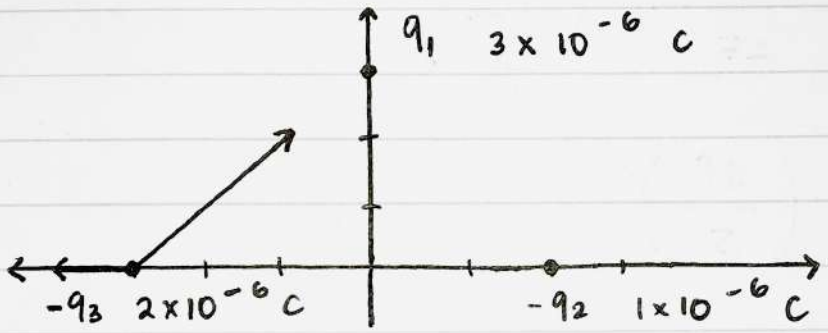
Date 21 Maret 2021

Hukum Coloumb

- Semakin besar muatan maka semakin besar gaya
- Jarak memperlemah tarikan

Hukum Newton

$$F_g = G \frac{m_1 . m_2}{r^2}$$



$$F_{31} = K \frac{q_1 q_3}{r_{13}^2} \hat{r}_{13}$$

$$= K \frac{(3 \times 10^{-6})(2 \times 10^{-6})}{(\sqrt{3^2 + 3^2})^2} \left(\frac{3\hat{j} - 3\hat{i}}{\sqrt{3^2 + 3^2}} \right)$$

$$= (9 \times 10^{-9}) \frac{(3 \times 10^{-6})(2 \times 10^{-6})}{(\sqrt{9+9})^2} \left(\frac{3\hat{j} - 3\hat{i}}{\sqrt{9+9}} \right)$$

$$= 9 \times 10^{-9} \frac{(3 \times 2)(10^{-6})}{18} \left(\frac{3\hat{j} - 3\hat{i}}{\sqrt{18}} \right)$$

$$= 9 \times 10^{-9} \frac{6 \times 10^{-6}}{18} \left(\frac{3\hat{j} - 3\hat{i}}{3\sqrt{2}} \right)$$

$$= 9 \times 10^{-9} \frac{1}{3} 10^{-6} \left(\frac{3\hat{j} - 3\hat{i}}{3\sqrt{2}} \right)$$

$$= 3 \times 10^{-3} \left(\frac{3\hat{j} - 3\hat{i}}{3\sqrt{2}} \right) = \frac{9 \times 10^{-3} \hat{j} - 9 \times 10^{-3} \hat{i}}{3\sqrt{2}}$$

No.

Date

$$F_{32} = K \frac{q_2 \cdot q_3}{r_{23}^2} \hat{r}_{23}$$

$$= 9 \times 10^{-9} \frac{1 \times 10^{-6} \cdot 2 \times 10^{-6}}{\sqrt{(5^2)^2}} \left(\frac{5i}{\sqrt{5^2}} \right)$$

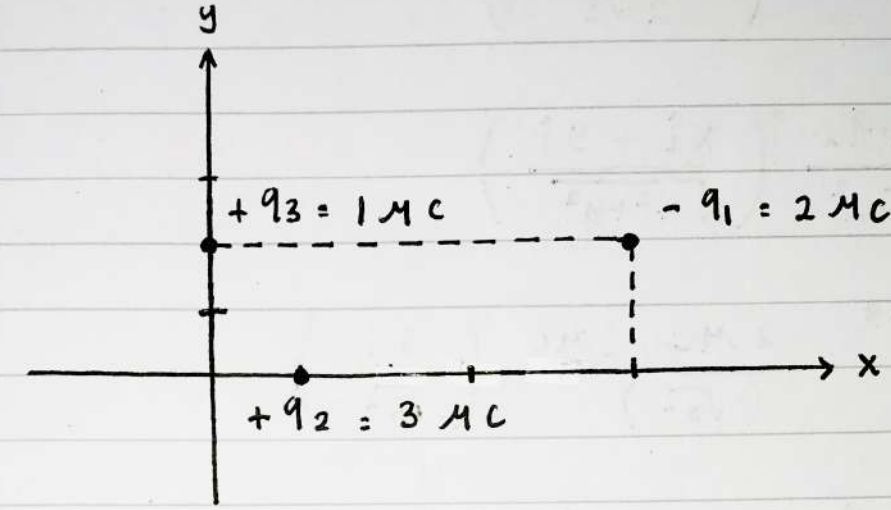
$$= 9 \times 10^{-9} \frac{2 \times 10^{-6}}{25} \left(\frac{5i}{5} \right)$$

$$= \frac{18 \times 10^{-3}}{25} \left(\frac{5\hat{i}}{5} \right)$$

$$= \frac{18 \times 10^{-3}}{25} \hat{i}$$

No.

Date



$$F_{12} = k \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$$

$$= 9 \times 10^{-9} \frac{2\mu C \cdot 3\mu C}{(\sqrt{2^2 + 2^2})^2} \left(\frac{2\hat{i} + 2\hat{j}}{\sqrt{2^2 + 2^2}} \right)$$

$$= 9 \times 10^{-9} \frac{6\mu C}{(\sqrt{8})^2} \left(\frac{2\hat{i} + 2\hat{j}}{\sqrt{4+4}} \right)$$

$$= 9 \times 10^{-9} \frac{6\mu C}{(8)} \left(\frac{2\hat{i} + 2\hat{j}}{\sqrt{8}} \right)$$

$$= 9 \times 10^{-9} \frac{3\ 6\mu C}{8\ 4} \left(\frac{2\hat{i} + 2\hat{j}}{2\sqrt{2}} \right)$$

$$= \frac{27\ \mu C}{4} \left(\frac{2\hat{i} + 2\hat{j}}{2\sqrt{2}} \right)$$

No.

Date

$$= \frac{27 \times 10^{-6}}{4} \left(\frac{2\hat{i} + 2\hat{j}}{2\sqrt{2}} \right)$$

$$F_{13} = K \frac{q_1 q_2}{r_{13}^2} \left(\frac{x\hat{i} + y\hat{j}}{\sqrt{x^2+y^2}} \right)$$

$$= 9 \times 10^{-9} \frac{-2\,\mu C \;\; 1\,\mu C}{(\sqrt{3^2})} \left(\frac{3\;1}{\sqrt{3^2}} \right)$$

$$= 9 \times 10^{-9} \quad \frac{-2\,\mu C}{9} \left(\frac{3i}{\sqrt{9}} \right)$$

$$= 9 \times 10^{-9} \quad \frac{-2\,\mu C}{9} \left(\frac{3i}{3} \right)$$

$$= -2\,\mu C \times 10^{-9}\, i$$

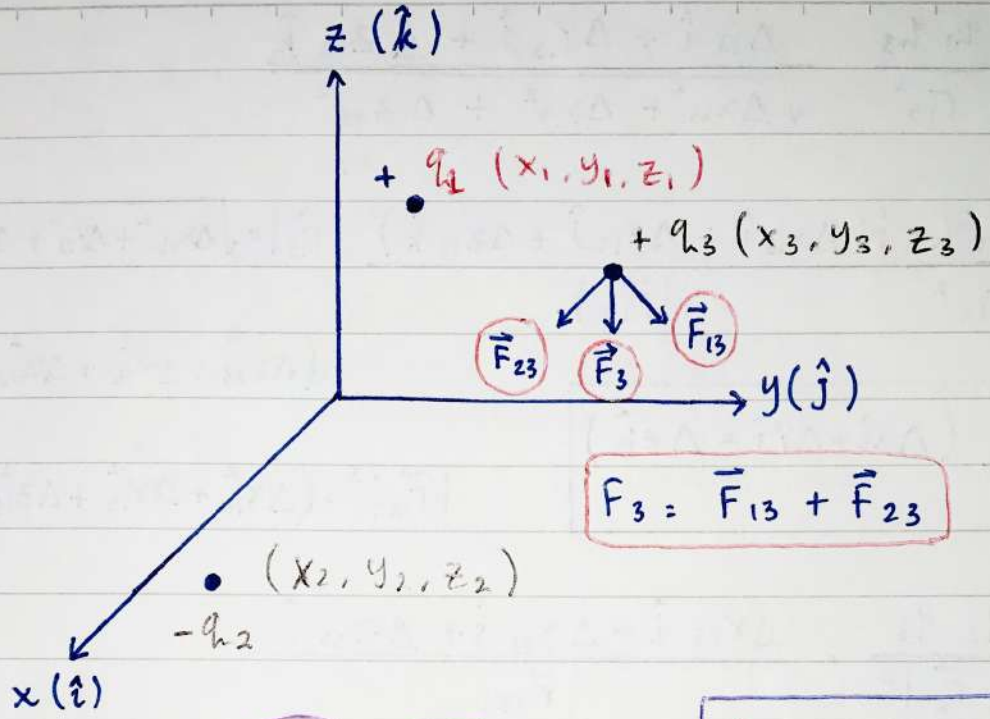
$$= (-2 \times 10^{-6})\, 10^{-9}\, i$$

$$= -2 \times 10^{-3}$$

$$F_{total} = \vec{F}_{12} + \vec{F}_{13}$$

$$= \left(\frac{54\hat{i} + 54\hat{j}}{4 \cdot 2\sqrt{2}} \right) 10^{-3} + (2i)\, 10^{-3} \quad N$$

$$= \left(\frac{54\hat{i} + 54\hat{j}}{4 \cdot 2\sqrt{2}} + 2i \right) 10^{-3}\, N$$



$$\vec{F}_3 = \vec{F}_{13} + \vec{F}_{23}$$

$$r_{12} = \Delta x\,\hat{i} + \Delta x\,\hat{j}$$
$$(x_2 - x_1) + (y_2 - y_1)$$

$$\hat{r}_{12} = \frac{\Delta x\,\hat{i} + \Delta x\,\hat{j}}{\sqrt{\Delta x^2 + \Delta y^2}}$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}^2}\,\hat{r}_{12}$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1 q_2}{(r_{12}^2)}\left(\frac{\Delta x\,\hat{i} + \Delta y\,\hat{j}}{\sqrt{\Delta x^2 + \Delta y^2}}\right)$$

$|r_{13}|^2 \qquad (r_{13})$

$$r_{13} = |\vec{r}_{13}|$$

$$= F_{12} = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1 q_2}{|\vec{r}_{12}|^3}\,(\Delta x\,\hat{i} + \Delta y\,\hat{j})$$

$$\Delta x = x_3 - x_1$$
$$\Delta y = y_3 - y_1$$
$$\Delta z = z_3 - z_1$$

No.

Date

$$\vec{F}_{13} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_3}{r_{13}^2} \frac{\Delta_{13}\hat{i} + \Delta Y_{13}\hat{j} + \Delta Z_{13}\hat{k}}{\sqrt{\Delta x_{13}^2 + \Delta Y_{13}^2 + \Delta z_{13}^2}}$$

$$\vec{F}_{13} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_3}{r_{13}^2} \frac{(\Delta x_{13}\hat{i} + \Delta Y_{13}\hat{j} + \Delta z_{13}\hat{k})}{|\vec{r}_{13}|} \quad |\vec{r}_{13}| = \sqrt{\Delta x_{13}^2 + \Delta Y_{13}^2 + \Delta z_{13}}$$

$$= (\Delta x_{13}^2 + \Delta Y_{13}^2 + \Delta Z_{13}^2)^{1/2}$$

$$\boxed{\vec{F}_{13} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_3}{|\vec{r}_{13}|^3} (\Delta x\hat{i} + \Delta Y\hat{j} + \Delta z\hat{k})}$$

$$|\vec{r}_{13}|^3 = (\Delta x_{13}^2 + \Delta Y_{13}^2 + \Delta Z_{13}^2)^{3/2}$$

$$\vec{F}_{23} = \frac{1}{4\pi\varepsilon_0} \frac{q_2 . q_3}{|\vec{r}_{23}|^2} \cdot \frac{\Delta x_{23}\hat{i} + \Delta Y_{23}\hat{j} + \Delta z_{23}\hat{k}}{|\vec{r}_{23}|}$$

$$\boxed{\vec{F}_{23} = \frac{1}{4\pi\varepsilon_0} \frac{q_2 . q_3}{|\vec{r}_{23}|^3} \Delta x_{23}\hat{i} + \Delta Y_{23}\hat{j} + \Delta z_{23}\hat{k}}$$

$$\vec{F}_3 = \frac{1}{4\pi\varepsilon_0} \left[\overset{a}{\left(\frac{q_1 q_3}{|\vec{r}_{13}|^3}\right)} \left(\overset{a}{\Delta x_{13}}\hat{i} + \overset{a}{\Delta Y_{13}}\hat{j} + \overset{a}{\Delta z_{13}}\hat{k} \right) + \overset{b}{\left(\frac{q_2 q_3}{|\vec{r}_{23}|^3}\right)} (\Delta x_{23}\hat{i} + \Delta Y_{23}\hat{j} + \Delta z_{23}\hat{k}) \right]$$

$$\vec{F}_3 = \frac{1}{4\pi\varepsilon_0} \left[(a . \Delta x_{13} + b\Delta x_{23})\hat{i} + (a . \Delta Y_{13} + b\Delta Y_{23})\hat{j} + (a . \Delta z_{13} + b\Delta z_{23})\hat{k} \right]$$

$$\vec{F}_3 = K\left[\left(\frac{q_1 q_3}{|\vec{r}_{13}|^3} . \Delta x_{13} + \frac{q_1 q_3}{|\vec{r}_{23}|^5} \right)\hat{i} + \left(\frac{q_1 q_3}{|\vec{r}_{13}|^3} . \Delta x_{13} + \right. \right.$$

$$\frac{q_2 q_3}{|\vec{r}_{23}|^3} \Delta Y_{23}\Big)\hat{j} + \Big(\frac{q_1 q_3}{|\vec{r}_{13}|^3} \cdot \Delta Z_{13} + \frac{q_2 q_3}{|\vec{r}_{23}|^3} \cdot \Delta Z_{23}\Big)\hat{k}\Big]$$

$$\vec{F}_3 = K\, q_{13}\Big[\Big(\frac{q_1}{|\vec{r}_{13}|^3} \cdot \Delta X_{13} + \frac{q_2}{|\vec{r}_{23}|^3} \Delta X_{23}\Big)\hat{i} + \Big(\frac{q_1}{|\vec{r}_{13}|^3} \cdot \Delta Y_{13} +$$

$$\frac{q_2}{|\vec{r}_{23}|^3} \Delta Y_{23}\Big)\hat{j} + \Big(\frac{q_1}{|\vec{r}_{13}|^3} \Delta Z_{13} + \frac{q_2}{|r_{23}|^3} \Delta Z_{23}\Big)\hat{k}\Big]$$

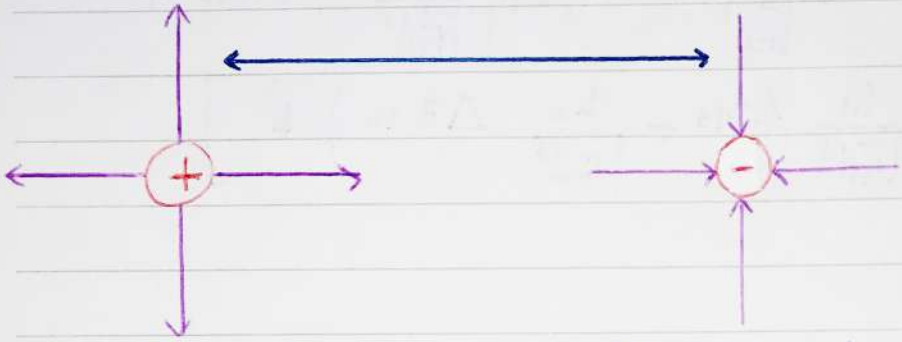
No. Kamis

Pak Fatkhur Pert. (9)

Date 25 April 2024

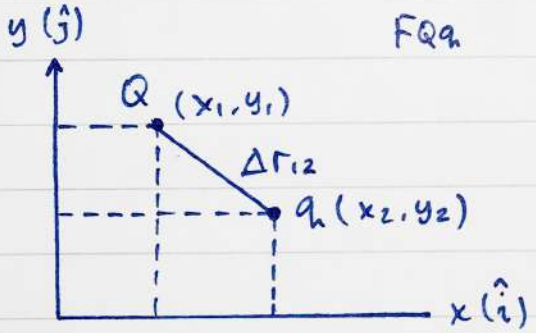
Medan Listrik

↳ Area atau wilayah di sekitar muatan listrik yang masih terpengaruh oleh gaya listrik.



Muatan utama
Q

Muatan uji
q_n



$E_{Qq_n} = q_n \cdot E_Q$ → medan listrik yg dihasilkan

(muatan uji)

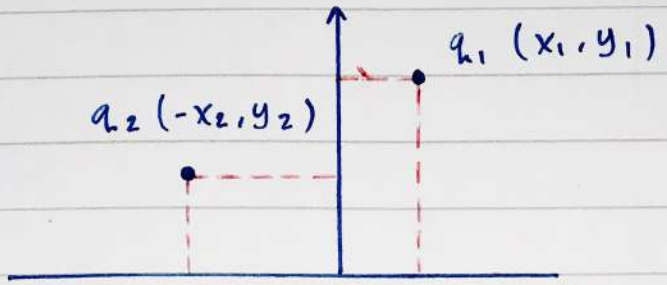
$$E_{Qq_n} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \cdot q_n}{r_{Qq_n}^2} \cdot \hat{r}_{Qq_n} \qquad \hat{r}_{Qq_n} = \frac{\Delta x\,\hat{i} + \Delta x\,\hat{j}}{\sqrt{\Delta x^2 + \Delta y^2}} = \frac{\vec{r}_{Qq_n}}{|\vec{r}_{Qq_n}|}$$

$$\cancel{q_n} E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \cdot \cancel{q_n}}{r_{Qq_n}^2} \cdot \hat{r}_{Qq_n} \qquad |\hat{r}_{Qq_n}| = r_{Qq_n} = \sqrt{\Delta x^2 + \Delta y^2}$$

$$E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_{Qq_n}^2} \cdot \hat{r}_{Qq_n} \rightarrow \boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_{Qq_n}^3} \cdot \vec{r}_{Qq_n}}$$

No.

Date . .

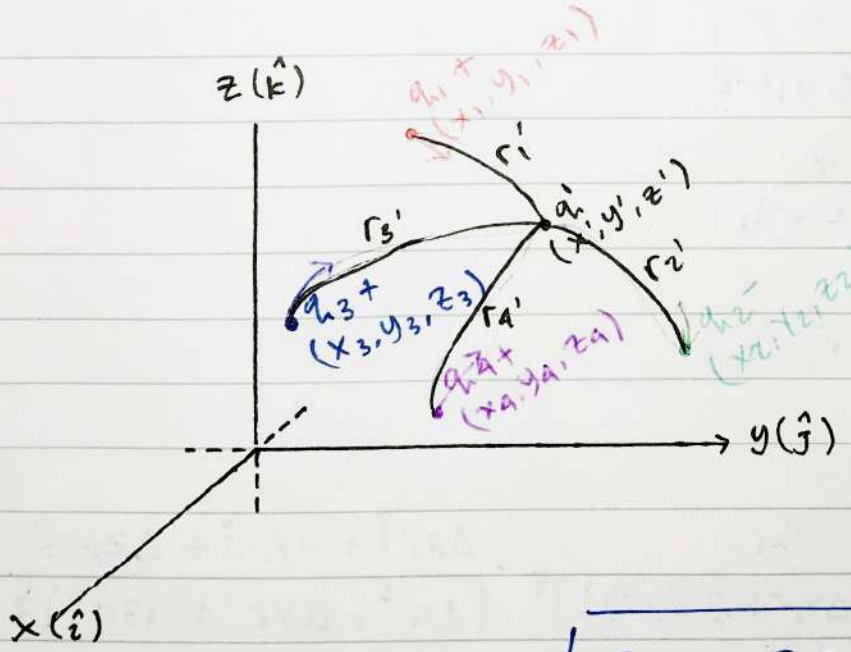


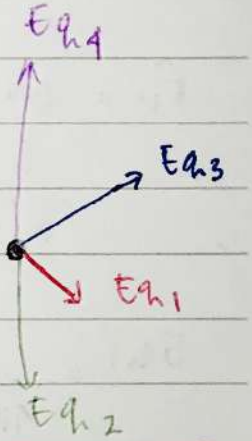
medan listrik yg dihasilkan oleh :

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

$$Eq_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{r_{21}^2} \cdot \hat{r}_{21}$$

- Medan Listrik yg dihasilkan oleh Banyak Muatan.





$q_1 < q_2 < q_3 < q_4$

$$E_{total} = Eq' = Eq_1 + Eq_2 + Eq_3 + Eq_4$$

No.

Date . .

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

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

$$E_{q_3} = \frac{1}{4\pi\varepsilon_0} \frac{q_3}{r_{3'}^2} \hat{r}_{3'}$$

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

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

$$\hat{r}_{1'} = \Delta x_{1'}\hat{i} + \Delta y_{1'}\hat{j} + \Delta z_{1'}\hat{k}$$

$$\downarrow \quad \downarrow \quad \downarrow$$

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

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

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

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2) \cdot (\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}}$$

$$(\Delta x_{1'}\hat{i} + \Delta y_{1'}\hat{j} + \Delta z_{1'}\hat{k})$$

No.

Date

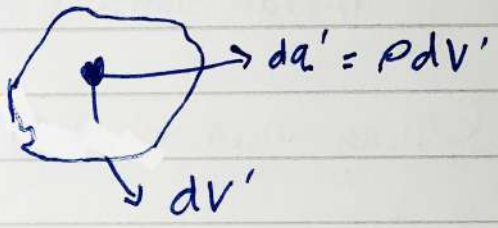
- Medan listrik yg dihasilkan oleh distribusi muatan.

	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	$dx\,dy, dy\,dz, dz\,dx$	$d\rho\,dz, \rho d\phi\,dz, \rho d\phi\,d\rho$	$r\,dr\,d\theta, r\sin\theta\,dr\,d\phi, r^2 \sin\theta\,d\theta\,d\phi$
dV	$dx\,dy\,dz$	$\rho\,d\rho\,d\phi\,dz$	$r^2 \sin\theta\,dr\,d\theta\,d\phi$

a. Rapat muatan volume (dv') atau (dV')

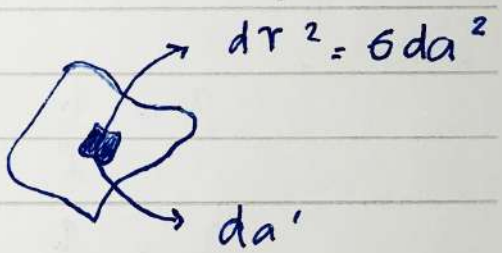
$$\rho = \frac{dq'}{dV'} \qquad (1.23)$$

$$\rho = \frac{dr}{dq'} \qquad (1.24)$$



b. Rapat muatan luas (da')

$$\sigma = \frac{dq'}{da'} \qquad (1.25)$$

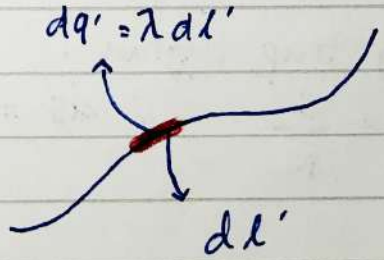


c. Rapat muatan panjang (ds') atau (dl')

$$\lambda = \frac{dq'}{dl'} \qquad (1.26)$$

atau

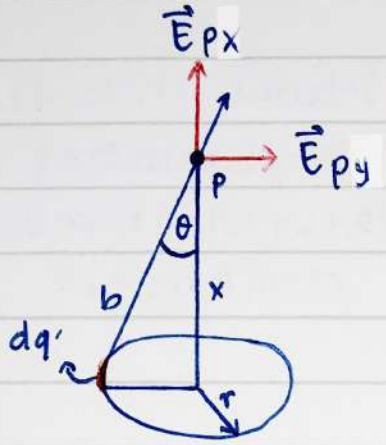
$$\lambda = \frac{ds'}{dq'} \qquad (1.27)$$



No.

Date . .

- Medan Listrik oleh Muatan Cincin



Medan listrik di sumbu

Keliling cincin = $2\pi r$

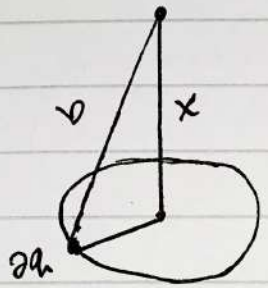
Kerapatan muatan cincin (muatan per panjang)

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

$$\lambda = \frac{q}{2\pi r}$$

bagi cincin atas bagian² kecil sejumlah N buah sebagai sampel,
panjang tiap bagian :

$$ds' = \frac{S}{N} \qquad ds = 2\pi dr$$



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

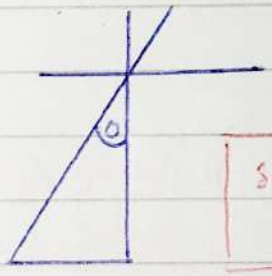
$$dL = 2\pi\, dr \qquad \lambda = \frac{dq}{dL}$$

$$\lambda = \frac{q}{2\pi r} \qquad dq = \lambda\, dL$$

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

depan = y

$$E_{dq} = \frac{1}{4\pi\varepsilon_0}\,\frac{dq}{b^2}$$



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

$$E_{dq} = \frac{1}{4\pi\varepsilon_0}\,\frac{\lambda\, dL}{(r^2+x^2)}$$

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

$$E_{dq} = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dL}{(r^2+x^2)}$$

$$E_{dqy} = E_{dq}\cdot\sin\theta = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dL}{(r^2+x^2)}\cdot\sin\theta$$

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

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

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

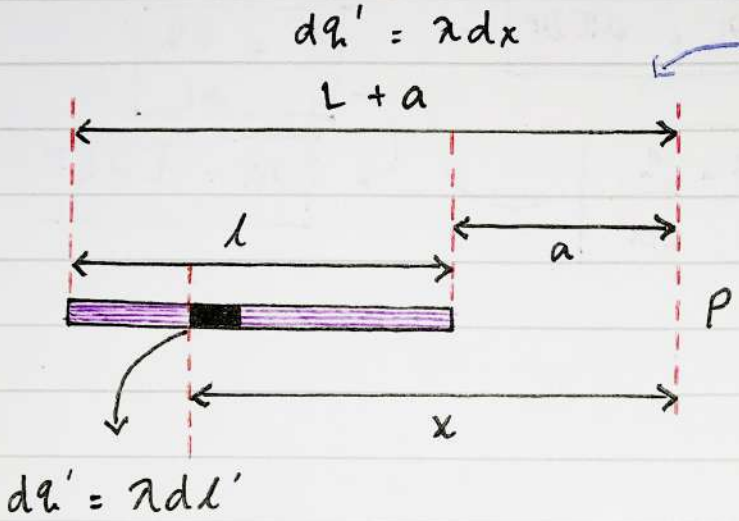
1.42

Aldo Raya

No.

Date

1.5.2. Medan Listrik oleh Muatan Batang



Medan Listrik yang dihasilkan oleh batang.

Medan yg dihasilkan elemen tersebut pada titik P adalah:

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

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

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

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \int_a^{l+a} \left[\frac{1}{x^2}\right] dx$$

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

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

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

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

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

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

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

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