29-02-2024

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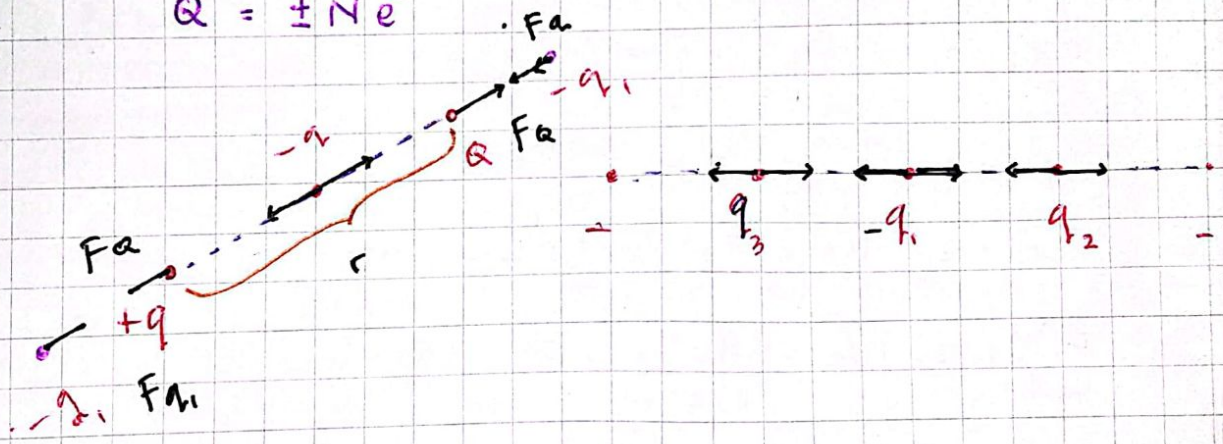
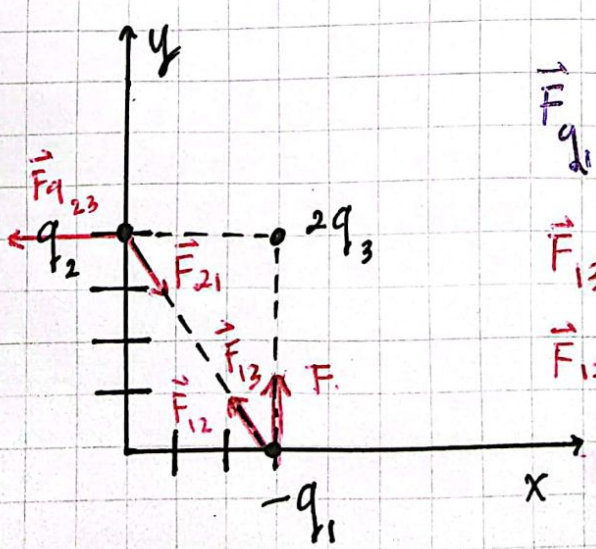
# LISTRIK STATIS

- Gaya Coulomb
- Medan Listrik
  - diskrit
  - non diskrit → Coulomb, Gausias, Statis
- Potensial
  - diskrit
  - non diskrit
- Usaha dan Energi

$Q = \pm N e^-$




$$a = \frac{F}{M} \qquad \vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{r^2}\hat{r}_0 \qquad \hat{r}_0 = \frac{\vec{r}}{|r|}$$




$\vec{F}_{q_1} =$

$$\vec{F}_{13} = \frac{k\,q_1(2q_3)}{4^2}\hat{j} = \frac{2kq_1q_3}{16}$$

$$\vec{F}_{12} = k\,\frac{q_1q_2}{5^2}\,\frac{(-3\hat{i}+4\hat{j})}{5^2}$$

$$\vec{F} = kq_1\left[-\frac{3q_2}{125}\hat{i} + \left(\frac{2q_3}{16} + \frac{4q_2}{125}\right)\hat{j}\right]$$

$$|\vec{F}| = kq_1\sqrt{0^2 + \square^2}$$

$$\vec{F}_{12} = k\frac{q_1q_2}{5^2}\left(\frac{-3\hat{i} + 4\hat{j}}{5}\right)$$

$$= \frac{-3kq_1q_2}{125}\hat{i} + \frac{4kq_1q_2}{125}$$

$$\vec{F} = \left[\frac{-3kq_1q_2}{125}\hat{i} + \left(\frac{2kq_1q_3}{16} + \frac{4kq_1q_2}{125}\right)\hat{j}\right]$$

$$= kq_1\left[-\frac{3q_2}{125}\hat{i} + \left(\frac{2q_3}{16} + \frac{4q_2}{125}\right)\hat{j}\right]$$

$$\vec{F}_{21} = k\frac{q_2q_1}{5^2}\left(\frac{-4\hat{j} + 3\hat{i}}{5}\right)$$

$$= -\frac{4kq_2q_1}{125}\hat{j} + \frac{3kq_2q_1}{125}\hat{i}$$

$$\vec{F}_{23} = \frac{-kq_2q_3}{2^2}\hat{i} = -\frac{2kq_2q_3}{2^2}\hat{i}$$

$$\vec{F} = \left[\left(\frac{3kq_2q_1}{125} + \frac{2kq_2q_3}{4}\right)\hat{i} - \frac{4kq_2q_1}{125}\hat{j}\right]$$

$$= kq_2\left[\left(\frac{3q_1}{125} + 2q_3\right)\hat{i} - \frac{4q_1}{125}\hat{j}\right]$$

# LISTRIK STATIS

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

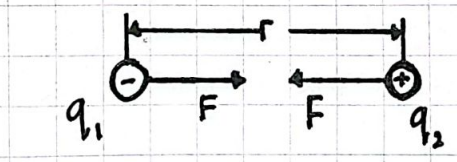
## → MUATAN LISTRIK

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.



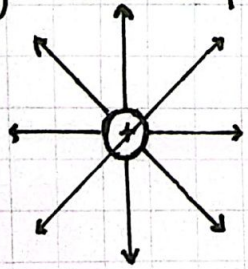


$$F = k\frac{q_1 q_2}{r^2} \qquad F = k\frac{q_1 q_2}{r^2}\hat{r}$$

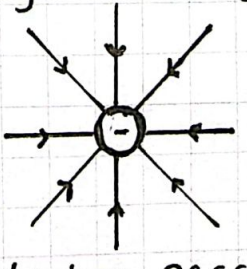
$$k = 9 \times 10^9 \ Nm^2/C^2$$

## 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 diletakkan dalam pengaruh medan listrik muatan sumber disebut sebagai muatan uji.

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

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.

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

V = potensial listrik

## 4. ENERGI POTENSIAL LISTRIK

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

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

# LISTRIK STATIS

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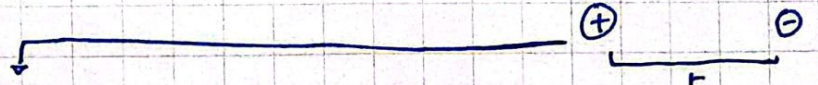
## ✓ Hukum Coulomb

- Berkaitan dengan hubungan dua muatan




$$k = \frac{1}{4\pi\varepsilon_0}$$

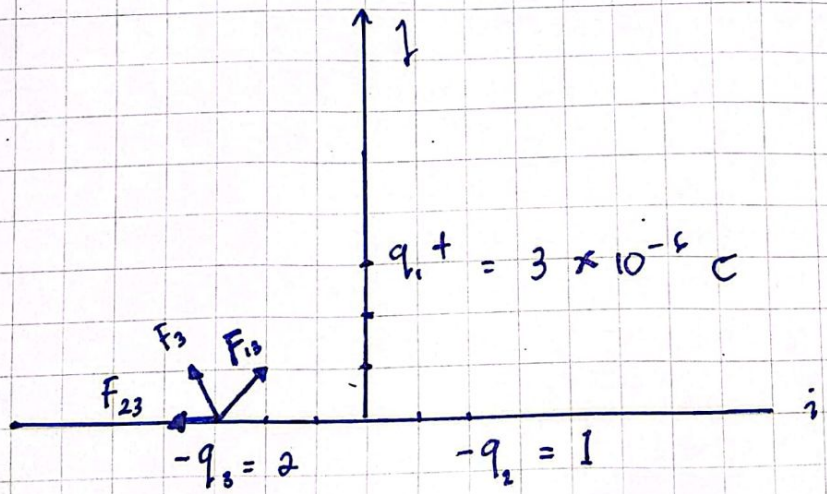
Konsepannya bagaimana?

$$F_{q_1 q_2} = k\frac{q_1 \cdot q_2}{r^2} \qquad F \simeq q_1 q_2 \qquad F_{q_1 q_2} \simeq \frac{1}{r^2}$$

- Mirip dengan konsep gravitasi bumi

$$F_g = G\frac{M_1 M_2}{r^2}$$ Gaya gravitasi antar planet.

$$\vec{F}_{q_1 q_2} = \frac{k\, q_1 q_2}{r^2}\hat{r} \qquad \hat{r} = \frac{x\hat{i} + y\hat{j}}{\sqrt{x^2 + y^2}} = \frac{\vec{r}}{|r|}$$




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

$$F_{13} = 9\times 10^9 \frac{3\times10^{-6}\cdot 2\times10^{-6}}{(\sqrt{3^2+8^2})^2}\frac{3\hat{j}-3\hat{i}}{\sqrt{3^2+3^2}}$$

$$= \frac{54}{18}\times 10^{-3}\left(\frac{3\hat{j}-3\hat{i}}{3\sqrt{2}}\right)$$

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

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

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

$$= 9 \times 10^9 \cdot \frac{1 \times 10^{-6} \cdot 2 \times 10^{-6}}{5^2} \frac{5\hat{i}}{\sqrt{25}}$$

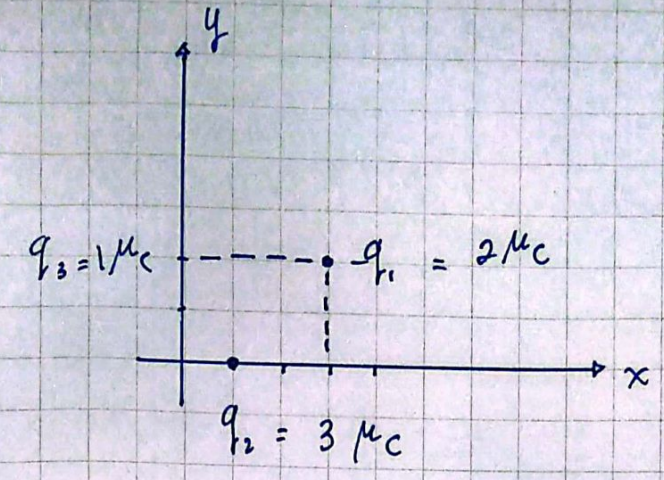
$$= \frac{18}{25} \times 10^{-3} \frac{5\hat{i}}{5}$$

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

$$F_3 = F_{13} + F_{23}$$

$$= \left( \frac{9\hat{j}}{3\sqrt{2}} - \frac{9\hat{i}}{3\sqrt{2}} \right) 10^{-3} \text{ N} + \left( \frac{18\hat{i}}{25} \right) 10^{-3} \text{ N}$$

$$= \left( \left( \frac{18}{25} - \frac{9}{3\sqrt{2}} \right) \hat{i} + \frac{9}{3\sqrt{2}} \hat{j} \right) 10^{-3} \text{ N}$$




$$F_{21} = k\frac{q_2 q_1}{r^2}\hat{r}$$

$$= 9\times10^9\ Nm^2/C^2\ \frac{3\times10^{-6}C\cdot 2\times10^{-6}C}{(\sqrt{2^2+2^2})^2}\ \frac{2\hat{i}+2\hat{j}}{\sqrt{2^2+2^2}}$$

$$= \frac{54}{8}\times10^{-3}\ N\ \frac{2\hat{i}+2\hat{j}}{\sqrt{2^2+2^2}}$$

$$= \frac{54\times10^{-3}}{8}\ N\ \frac{2\hat{i}+2\hat{j}}{2\sqrt{2}}$$

$$= \frac{27}{4}\times10^{-3}\ N\ \frac{2\hat{i}+2\hat{j}}{2\sqrt{2}}$$

$$= \left(\frac{54\,i}{4\cdot2\sqrt{2}} + \frac{54\,j}{4\cdot2\sqrt{2}}\right)10^{-3}\ N$$

$$F_{31} = k\frac{q_3 q_1}{r^2}\hat{r}$$

$$= 9\times10^9\ Nm^2/C^2\ \frac{1\times10^{-6}C\cdot 2\times10^{-6}C}{3^2}\ \frac{3\hat{i}}{\sqrt{3^2}}$$

$$= \frac{18}{9}\times10^{-3}\ N\ \frac{3\hat{i}}{3}$$

$$= \frac{18}{9}\,i\times10^{-3}\ N$$

$$= 2\,i\times10^{-3}\ N$$

$$F_1 = F_{21} + F_{31}$$

$$= \left(\left(\frac{54\,i+54\,j}{4\cdot2\sqrt{2}}\right)10^{-3} + \left(2\,i\right)10^{-3}\right)N$$

$$= \left(\frac{54\,i+54\,j}{4\cdot2\sqrt{2}} + 2\,i\right)10^{-3}\ N$$

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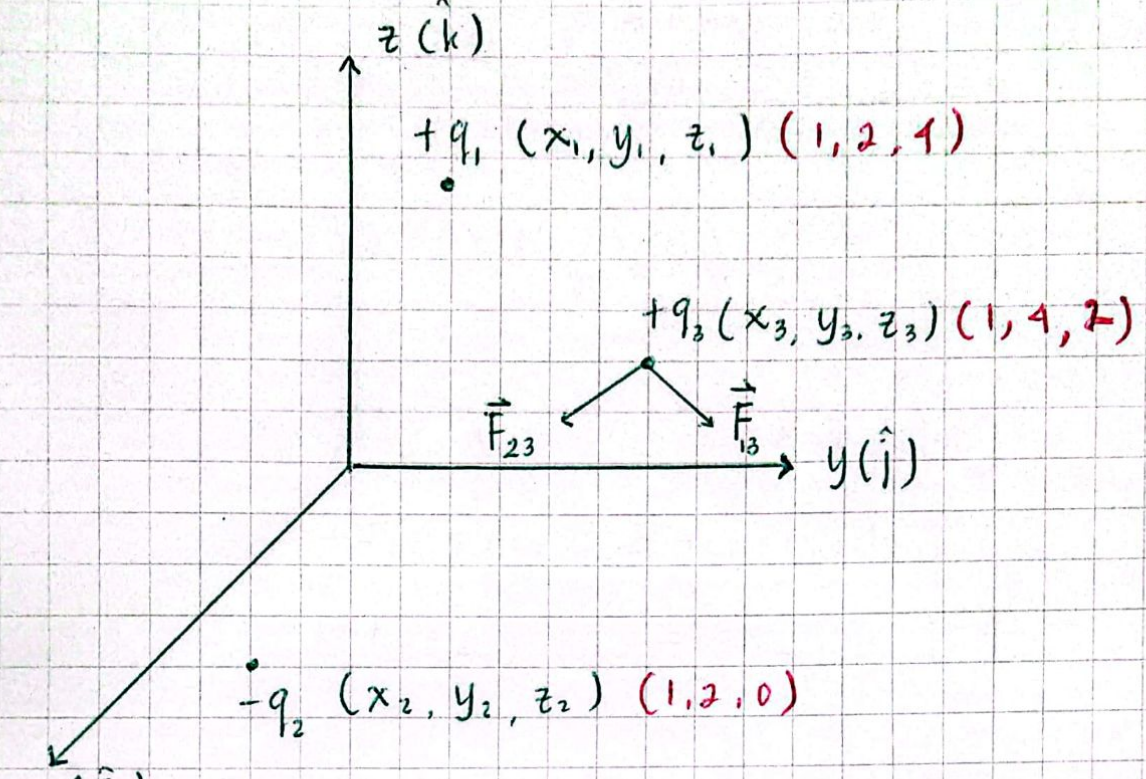


$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$$

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

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

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

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

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

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

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

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

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

Note:

$$|\vec{r}_{13}| = \sqrt{\Delta x_{13}^2 + \Delta y_{13}^2 + \Delta z_{13}^2}$$

$$= (\Delta x_{13}^2 + \Delta y_{13}^2 + \Delta z_{13}^2)^{\frac{1}{2}}$$

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

$$\therefore \vec{F}_{23} = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{|\vec{r}_{23}|^2}\frac{\Delta x_{23}\hat{i} + \Delta y_{23}\hat{j} + \Delta z_{23}\hat{k}}{|\vec{r}_{13}|}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{|r_{23}|^3}\Delta x_{23}\hat{i} + \Delta y_{23}\hat{j} + \Delta z_{23}\hat{k}$$

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

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

$$\vec{F}_3 = k$$