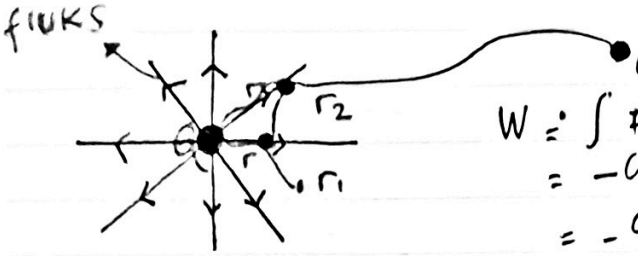
22/4 2024

KALISMA

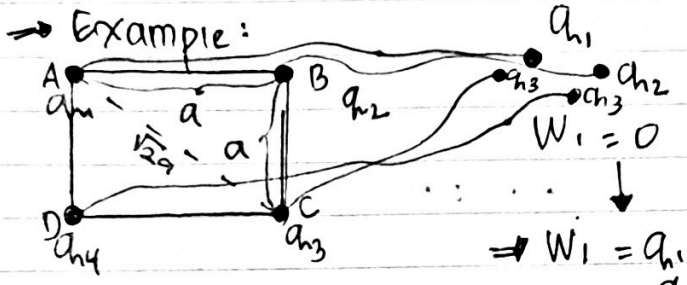
# Usaha dan Energi Dalam Listrik Statis




$$W = \int F \cdot dr$$
$$= -q_h \int E \, dr$$
$$= -q_h \left[ -K \frac{Q}{r} \right]$$

$W = q_h \cdot V$ → V = potensial energi

→ Example:




$W_1 = 0$ karena di dalam kotak ∴ tidak ada muatan ($V_1 = 0$)

$$\Rightarrow W_1 = q_1 \cdot V_1$$
$$= q_1 \cdot 0$$
$$W_1 = 0$$

$\Rightarrow W_2 = q_2 V_2$

$V_2 = K \frac{q_1}{a}$ $\Rightarrow W_2 = K \cdot q_2 \frac{q_1}{a} = K \frac{q_1 \cdot q_2}{a}$

↳ aslinya r. r pada soal itu a. Makanya r diganti a.

$\Rightarrow V_3 = K \frac{q_1}{\sqrt{2}a} + K \frac{q_2}{a}$ $\Rightarrow W_3 = K \left[ \frac{q_1 \cdot q_3}{\sqrt{a}} + \frac{q_2 \cdot q_3}{a} \right]$ $\Rightarrow W_3$ itu mencari A dan B.

$\Rightarrow V_4 = K \left[ \frac{q_1}{a} + \frac{q_2}{\sqrt{2}a} + \frac{q_3}{a} \right]$ $\Rightarrow W_4 = K \left[ \frac{q_1 \cdot q_4}{a} + \frac{q_2 \cdot q_4}{\sqrt{2}a} + \frac{q_3 \cdot q_4}{a} \right]$

Dari $q_2$ ke $q_4$ $\sqrt{2}a$ karena dari Phitagoras.

$$\Rightarrow W_{tot} = W_1 + W_2 + W_3 + W_4$$
$$= \sum_{i=1}^{n} \sum_{j \neq i}^{M} q_i \frac{q_j}{4\pi\varepsilon_0 r_i}$$
$$= \frac{1}{8\pi\varepsilon_0} \sum_{i=1}^{n} q_i \sum_{j \neq 1}^{n} \frac{q_j}{r_{ij}}$$
$$= \frac{1}{2} \sum_{i=1}^{n} q_i \sum_{j \neq 1}^{n} \frac{1}{4\pi\varepsilon_0 r_{ij}} q_j$$

$$\Rightarrow W = \frac{1}{2} \sum_{i=1}^{n} q_i \sum_{j \neq i}^{n} V_j$$

$$W = \frac{1}{2} \sum_{i=1}^{n} q_i \sum_{j \neq i}^{n} V_j$$

Jadi i sama j gak akan kembar. Kalo $i = 1$, maka $j = 2/3$ dst

$$W = \frac{1}{2} \sum_{i=1}^{n} q_i \sum_{j \neq i}^{n} V_j$$

integral lipat 1 karena dl

$\Rightarrow W = \frac{1}{2} \int \alpha V \, d\vec{l}$ $\Rightarrow$ Potensial oleh muatan pada garis

integral lipat 2 karena ds

$\Rightarrow W = \frac{1}{2} \int \sigma V \, d\vec{s}$ $\Rightarrow$ Potensial oleh muatan pada permukaan

integral lipat 3 karena $d\tau$

$\Rightarrow W = \frac{1}{2} \int \rho V \, d\tau$ $\Rightarrow$ Potensial oleh muatan pada Volume

$W = \frac{\varepsilon_0}{2} \int (\nabla . E) V \, d\tau_\rho \rightarrow W = \frac{\varepsilon_0}{2} \int E^2 \, d\tau$

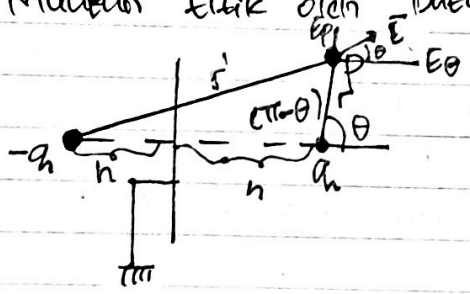
$\Rightarrow \rho = \varepsilon_0 \cdot \nabla . \vec{E} \rightarrow \nabla . \vec{E} = \frac{\rho}{\varepsilon_0}$ $\Rightarrow$ Rumus hukum gauss.

Hukum gauss terjadi karau ada sumber muatan.

↳ Medan yang melingkupi sebuah muatan $\rightarrow \oint E \, d\vec{a} = Q/\varepsilon_0$

$\Rightarrow$ Metode bayangan

→ Muatan titik oleh batang konduktor, Ditanya = $V_p$ ...?

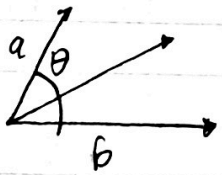



$\pi = 180$

$$V_p = k \left[ \frac{q_h}{r} + \frac{-q_h}{r'} \right]$$

$$E_\theta = -\frac{1}{r} \frac{\partial V}{\partial r}$$

$$E_r = -\frac{\partial V}{\partial r}$$




$$r' = r^2 + 2h^2 + 4hr\cos(\pi - \theta)^{1/2}$$

$$V_p = k \left[ \frac{q_h}{r} + \frac{-q_h}{r'} \right]$$

$$= k q_h \left[ \frac{1}{r} - \frac{1}{r^2 + 2h^2 + 4hr\cos(\pi - \theta))^{1/2}} \right]$$

$$V_p = k q_h \left[ \frac{1}{r} - \frac{1}{(r^2 + 4h^2 + 4hr\cos\theta)^{1/2}} \right]$$

ini gak diturunin karena gak ada unsur r

$-1/2 + 2 = 3/2$

$\frac{1}{r} = r^{-1} \, dr$

$= -r^{-1-1}$

$= -r^{-2} = -\frac{1}{r^2}$

$$\Rightarrow E_r = -\frac{\partial V}{\partial r}$$

$$E_r = -kq\left[-\frac{1}{r^2} - \frac{-1/2\,(r^2+4h^2+4hr\cos\theta)^{-1/2}\,(2r+4h\cos\theta)}{(r^2+4h^2+4hr\cos\theta)^{1}}\right]$$

karena itu $4h^2$ ilang, karena gak ada unsur r waktu di turunin

$$E_r = -kq\left[-\frac{1}{r^2} + \frac{(r+2h\cos\theta)}{(r^2+4h^2+4hr\cos\theta)^{3/2}}\right]$$

$3/2$ didapat dari $1/2 + \frac{2}{2} = 3/2$

$$E_r = kq\left[\frac{1}{r^2} - \frac{(r+2h\cos\theta)}{(r^2+4h^2+4hr\cos\theta)^{3/2}}\right]$$

$$\Rightarrow E_\theta = \frac{\partial V}{\partial \theta}$$

$$= -kq\left[\frac{-1/2\,(r^2+4h^2+4hr\cos\theta)^{-1/2}\,(4hr\sin\theta)}{(r^2+4h^2+4hr\cos\theta]}\right]$$

$$E_\theta = -kq\left[\frac{2hr\sin\theta}{[r^2+4h^2+4hr\cos\theta]^{3/2}}\right]$$

jadi 2 karena 4 dikali $1/2$, (-) ikang karena dikali - yang kq