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Resume Potensial listrik

Sifat khusus dari ~~muatan~~ medan listrik $\vec{E}$ yaitu :

$\nabla \times \vec{E} = 0$, ini artinya medan $\vec{E}$ merupakan gradien suatu skalar, Jadi
$\vec{E} \sim \nabla \varphi$, maka $\nabla \times \vec{E} = 0$

Menurut teorema stokes

$$\oint \vec{E}\, d\vec{p} = \int \nabla \times \vec{E}\, d\vec{s} = 0$$

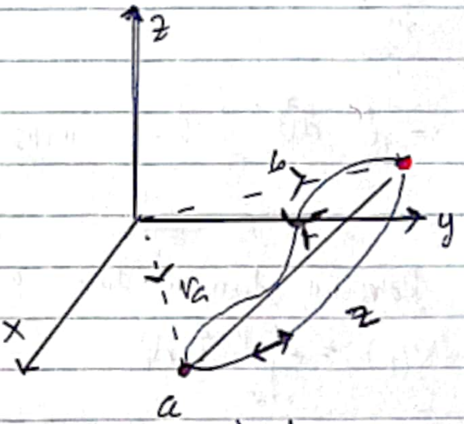
Artinya $\oint_a^b \vec{E}\, d\vec{p}$ tidak bergantung pada Pilihan jalan a ke b

$\vec{E} = -\nabla V$

$E\cdot dl = -\nabla V \cdot d\vec{p} = -dv$

$\int \vec{E}\cdot\vec{u} = \int_a^b -dv$

$\int \vec{E}\cdot\vec{u} = V_2 - V_d$



Uji lintasan tertutup

$V_b = V_a$

$V_b - V_a = 0$

Hal ini berlaku untuk medan $\vec{E}$ dari suatu muatan titik di titik asal atau dari setiap konfigurasi muatan yang statis.

$\int \vec{E}\cdot d\vec{p} = 0$ bila lintasan a ke b tertutup, melalui Jalan I ada 2 harga . $\oint \vec{E}\cdot d\vec{p} \neq 0$, karena (r, φ, r_2)

$\downarrow$

harus lepas stokes

Selanjutnya : $\vec{E} = -\nabla V$. ($\vec{E}$ mrp gradien Potensial)

$\oint \vec{E}\cdot d\vec{p} = \int \nabla \times E\, d\vec{s}$

$d\vec{s} \neq 0$, maka
$\nabla \times \vec{E} = 0$

$E = -\nabla V$

$\nabla \vec{E} = -\nabla \cdot \nabla V$

$\nabla \cdot \vec{E} = -\nabla^2 V$

$\rho / \varepsilon_0 = -\nabla^2 V$

$\nabla^2 V = -\frac{\rho}{\varepsilon_0}$

$E = -dv$

$E \cdot dp = -dv \cdot dp$

$\int_a^b E\, dP = \int_a^b dv$

$\int_a^b dv = V_b - V_a$
$= V_b = V_a$

Jika $V_a + V_b$

$$\nabla V \cdot d\vec{p} = dV$$

$$E = -\nabla V$$

$\int \vec{E} \cdot d\vec{p} = -\int \nabla V \cdot d\vec{p} = -\int dV$, jadi potensial diatas $V_b = 1 \frac{Q}{p^2}$

$$V(a) = -\int_{\infty}^{a} \vec{E}\, d\vec{p}$$

$$V(b) = -\int_{\infty}^{b} \vec{E}\, d\vec{p}$$

$$V_{ab} = V_b - V_a = -\int_{\infty}^{b} \vec{E} \cdot d\vec{p} + \int_{\infty}^{a} \vec{E} \cdot d\vec{p} = -\int_{a}^{b} \vec{E} \cdot d\vec{p}$$

$$= -\int_{a}^{b} E\, d\vec{p} - \int_{a}^{b} E \cdot d\vec{p} = -\int_{a}^{b} \vec{E}\, d\vec{p}$$

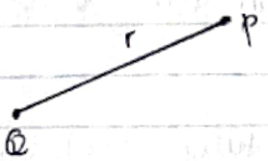
$$V_b - V_a = -\int_{a}^{b} \vec{E} \cdot d\vec{p}$$

$$\boxed{V(p) = -\int \vec{E} \cdot d\vec{p}} \rightarrow \text{Rumus umum}$$

Jadi, potensial disuatu titik P

$$V(p) = -\int_{\infty}^{p} \hat{E} \cdot d\vec{p}$$

Misal :



$$V(p) = -\int_{\infty}^{r} \vec{E} \cdot d\vec{p}$$

$$= -\int_{\infty}^{r} \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2}\, dr$$

$$V(p) = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r}$$

Untuk sejumlah muatan $q_1, q_2, q_3 \ldots q_n$ masing² pada jarak $r_1, r_2, r_3 \ldots$ maka.

$$V(p) = \frac{1}{4\pi\varepsilon_0} \left[\frac{q_1}{r_1} + \frac{q_2}{r_2} \ldots + \frac{q_n}{r_n} \right]$$

Potensial oleh distribusi muatan

1) Untuk kawat

$$V(P) = \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda\, dr}{r}$$

2) Untuk distribusi Permukaan

$$V(P) = \frac{1}{4\pi\varepsilon_0} \int \frac{\sigma\, d\vec{s}}{r}$$

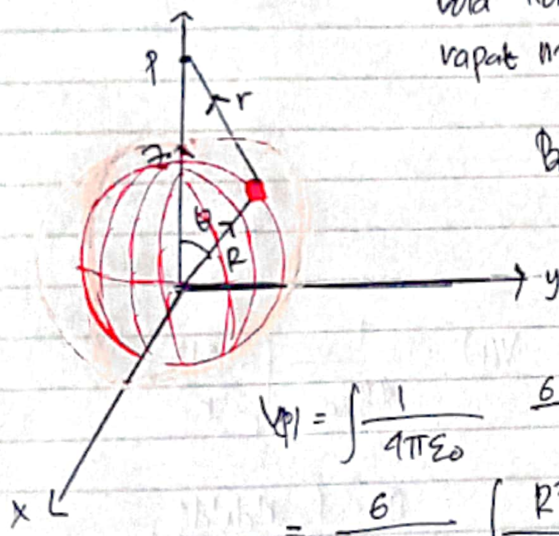
3) distribusi oleh volume

$$V(P) = \frac{1}{4\pi\varepsilon_0} \int \frac{\rho\, d\tau}{r}$$

Contoh :

1. Potensial oleh muatan Permukaan.

u.



bola konduktor bermuatan homogen dengan rapat muatan σ.

Berapa Potensial dititik P.

Solusi : distribusi muatan pada Permukaan bola ; maka

$$V_P = \int \frac{1}{4\pi\varepsilon_0} \frac{\sigma\, d\vec{s}}{r}$$

$$= \frac{\sigma}{4\pi\varepsilon_0} \int \frac{R^2 \sin\theta\, d\theta\, d\phi}{(z^2+R^2-2Rz\cos\theta)^{1/2}} \rightarrow |\vec{r}|$$

$$= \frac{\sigma R^2}{4\pi\varepsilon_0} \int_0^{\pi} \int_0^{2\pi} \frac{d\phi \sin\theta\, d\theta}{(z^2+R^2-2Rz\cos\theta)^{1/2}}$$

$$= \frac{2\pi\sigma R^2}{4\pi\varepsilon_0} \cdot \frac{1}{2} \int_0^{\pi} \frac{1}{Rz} \frac{d(-2Rz\cos\theta)}{(z^2+R^2-2Rz\cos\theta)^{1/2}}$$

$$= \frac{\sigma R}{\varepsilon_0 z} \left(2(z^2+R^2-2Rz\cos\theta) \right)_0^{\pi}$$

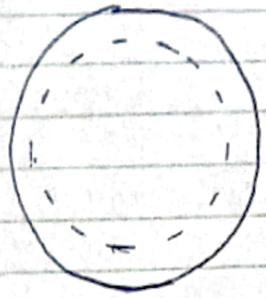
$$= \frac{\sigma R}{2\varepsilon_0 z}\left[(z^2+R^2+2Rz)^{1/2} - (z^2+R-2Rz)^{1/2} \right]$$

Potensial diatas dapat juga dihitung dengan rumus :

$$V(p) = -\int \vec{E}_z \cdot d\vec{z}$$

2) Potensial oleh muatan Volume

a.



bola dengan rapat muatan ρ = Konstan dengan jari-jari R. Hitung Potensial listrik pada

i $r < R$

i $r > R$

Solusi :

$r < R$, $E_1 \rightarrow \oint E_1 \, d\vec{s} = \frac{1}{\varepsilon_0} \rho V$

$$E_1 (4\pi r^2) = \frac{1}{\varepsilon_0} \rho \left(4/3 \, \pi r^3 \right)$$

$$E_1 = \frac{1}{3\varepsilon_0} \rho r \hat{s}$$

$r > R$, $E_2 \rightarrow \oint E_2 \, d\vec{s} = \frac{1}{\varepsilon_0} \rho V$

$$E_2 (4\pi r^2) = \frac{1}{\varepsilon_0} \rho \left(4/3 \, \pi R^3 \right)$$

$$E_2 = \frac{1}{3\varepsilon_0 r^2} \rho \cdot R^3 \hat{s}$$

$$V_1 = -\int \vec{E} \cdot d\vec{P} = -\int_{\infty}^{R} \vec{E}_2 d\vec{r} - \int_{R}^{r} \vec{E}_1 \cdot d\vec{r}$$

$$= \int_{\infty}^{R} \frac{1}{3\varepsilon_0 r^2} \rho R^3 \, dr - \int_{R}^{r} \frac{1}{3\varepsilon_0} \rho r \, dr$$

$$= -\frac{\rho R^3}{3\varepsilon_0} \int_{\infty}^{R} \frac{dr}{r^2} - \frac{\rho}{3\varepsilon_0} \int_{R}^{r} dr$$

$$= \frac{\rho R^2}{3\varepsilon_0} - \frac{\rho}{6\varepsilon_0} (r^2 - R^2)$$

$$= \frac{\rho R^2}{3\varepsilon_0} + \frac{\rho R^2}{6\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0} = \frac{2\rho R^2}{6\varepsilon_0} + \frac{\rho r^2}{6\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0}$$

$$V_1 = \frac{\rho r^2}{\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0}$$

$$\frac{3}{6}\frac{\rho r^2}{\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0}$$

$$\therefore V_1 = \frac{\rho}{\varepsilon_0}\left(R^2 - \frac{r^2}{6}\right)$$

$$= \frac{1}{6\varepsilon_0}\left(3\rho R^2 - \rho r^2\right)$$

$$= \frac{\rho}{6\varepsilon_0}\left(dR^2 - r^2\right)$$

$$V_2 = -\int_{\infty}^{r} \frac{1}{3\varepsilon_0 r^2} \rho_r{}^3 dr$$

$$= -\frac{\rho R^3}{3\varepsilon_0}\int_{\infty}^{r} \frac{dr}{r^2}$$

$$\therefore V_2 = \frac{\rho R^3}{3\varepsilon_0 r}$$

Dipindai dengan CamScanner