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Mata Kuliah : Kelistrikan & Kemagnetan

## Resume .

Potential listrik .

Sifat khusus dari potential listrik $\vec{E}$ yaitu

$\nabla \times \vec{E} = 0$, artinya medan $\vec{E}$ merupakan gradien suatu skalar, jadi

$\vec{E} \sim \nabla \phi$ , 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 $\oint_a^b \vec{E} \cdot d\vec{p}$ tidak bergantung pada pilihan jalan a ke b .

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

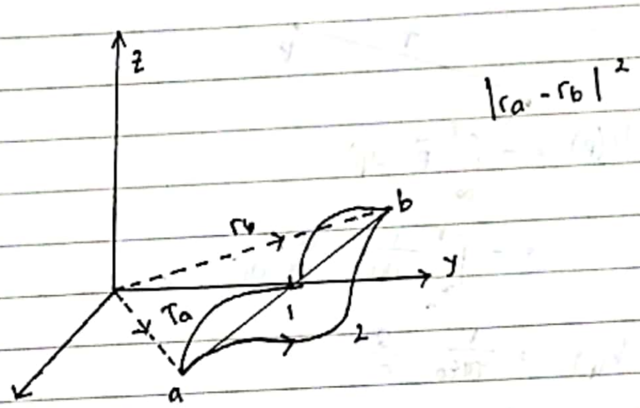
$E \cdot dp = -\nabla V \cdot d\vec{p}$

$= -dV$

$\int \vec{E} \cdot d\vec{p} = \int_a^b -dV$

$\int \vec{E}\, d\vec{p} = V_b - V_a$

y lintasan tertutup x .




$|r_a - r_b|^2$

$V_b = V_a$ $\Rightarrow$ berlaku untuk medan $\vec{E}$ dari suatu muatan titik .

$V_b - V_a = 0$ $\Rightarrow$ di titik asal atau dari setiap konfigurasi muatan yang statis .

Sehingga

$\int \vec{E}\, d\vec{p} = 0$ $\rightarrow$ Bila lintasan a ke b tertutup, melalui jalan 1 dan jalan 2

harga $\oint \vec{E} \cdot d\vec{p} \neq 0$, karena $(r_1 + r_2)$ .

$\downarrow$

baru kefor stokes Selanjutnya : $\vec{E} = -\nabla V$ ($\vec{E}$ merupakan gradien potential) .

$E = -\nabla V$

$\int_b^a \vec{E} \cdot d\vec{p} = \int \nabla \times E\, d\vec{s}$ $\quad \nabla \cdot \vec{E} = -\nabla \cdot \nabla V$ $\quad = -\int_b^a ede$ $\quad E = -\nabla V$

$d\vec{x} \neq 0$ , maka $\quad \nabla \cdot \vec{E} = -\nabla^2 V$ $\quad E\,dp = \nabla V\, de$

$\nabla \times E = 0$ $\quad \rho/\varepsilon_0 = -\nabla^2 V$ . $\quad \int_a^b ede = \int_a^b dV$

jika $V_a \neq V_b$ $\quad \Rightarrow \nabla^2 V = -\frac{\rho}{\varepsilon_0}$ $\quad = 0 \int_a^b dV = V_b - V_a$

$\boxed{V_b - V_a}$

$\hookrightarrow$ $\nabla V \cdot dp = dV$

$E = -\nabla V$ .

PAPERLINE

Dipindai dengan CamScanner

$\int \vec{E} \cdot d\vec{p} = -\int \nabla V \cdot d\vec{p} = -\int dV$, jadi persoalan di atas $V_b = +Q$

$$\left.\begin{aligned} V_{(a)} &= -\int_{\infty}^{a} \vec{E} \cdot d\vec{p} \\ V_{(b)} &= -\int_{a}^{b} \vec{E} \cdot d\vec{p} \end{aligned}\right\} V_{ab} = V_b - V_a = -\int_{g}^{b} \vec{E}\, dp + \int_{g}^{a} \vec{E}\, d\vec{p} = -\int_{a}^{b} \vec{E} \cdot d\vec{p}$$

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

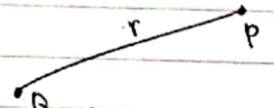
$$V_b - V_a = -\int_{a}^{b} \vec{E} \cdot d\vec{p}$$

$$\boxed{V_{(p)} = -\int \vec{E} \cdot d\vec{p}}$$ Rumus umum.

jadi potensial di suatu titik p .

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

Misal :




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

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

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

Untuk sejumlah muatan $q_1, q_2, q_3, \dots q_n$ masing-masing pada jarak $r_1, r_2, r_3, \dots r_n$, maka

$$V(p) = \frac{1}{4\pi\varepsilon_0} \left[ \frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \dots \frac{q_n}{r_n} \right] \Rightarrow \text{penjumlahan biasa.}$$

Potensial oleh distribusi muatan .

1.) Untuk kawat

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

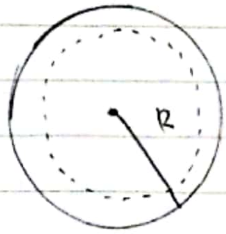
2.) Untuk distribusi oleh permukaan.

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

3.) distribusi oleh volume

$$V(p) = \frac{1}{4\pi\varepsilon_0} \int \frac{\rho\, db}{r}$$

* Potential oleh muatan volume

a. 

bola dengan rapat muatan $\rho$ = konstan, dengan jari-jari R. Hitung potential pada

i. $r < R$

ii. $r > R$

Solusi,

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

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

$$\vec{E}_1 = \frac{1}{3\varepsilon_0} \rho r\, \hat{r}_0$$

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

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

$$\vec{E}_2 = \frac{1}{3\varepsilon_0 r^2} \rho R^3 \hat{r}_0$$

$$V_1 = -\int \vec{E}\, d\vec{p} = -\int_\infty^R \vec{E}_2\, d\vec{r} - \int_R^r \vec{E}_1\, d\vec{r}$$

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

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

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

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

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

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

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

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

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

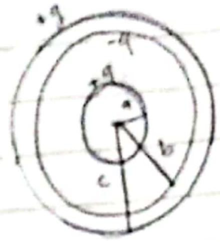
$$V_2 = -\int_\infty^r E_2\, dr$$

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

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

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

b.) Bola konduktor kosentris seperti pada gambar




1. $r < a$ : $E = 0$
2. $a < r < b$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

3. $b < r < c \rightarrow E = 0$
4. $r > c$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

$$V_1 = -\int_\infty^r \vec{E}\cdot d\vec{r}$$

$$= -\frac{q}{4\pi\varepsilon_0}\left[\int_\infty^c E_4 \, d\vec{r} + \int_c^b E_3 \, dr + \int_b^a E_2 \, dr + \int_a^r E_1 \, dr\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\int_\infty^c \frac{dr}{r^2} + \int_b^a \frac{dr}{r^2}\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[-\frac{1}{c} + \left(-\frac{1}{a} + \frac{1}{b}\right)\right]$$

$$\therefore V_1 = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{c} + \frac{1}{a} - \frac{1}{b}\right)$$

$$V_2 = \frac{-q}{4\pi\varepsilon_0}\left[\int_\infty^c \frac{dr}{r^2} + \int_c^b \frac{dr}{r^2} + \int_b^r \frac{dr}{r^2}\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\int_\infty^c \frac{dr}{r^2} + \int_b^r \frac{dr}{r^2}\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[-\frac{1}{c} + \left(-\frac{1}{r} + \frac{1}{b}\right)\right]$$

$$\therefore V_2 = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{c} + \frac{1}{r} - \frac{1}{b}\right)$$

$$V_3 = \frac{-q}{4\pi\varepsilon_0}\left[\int_\infty^c \frac{dr}{r^2} + \int_c^r \frac{dr}{r^2}\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left(-\frac{1}{c} + \left(-\frac{1}{r} + \frac{1}{c}\right)\right)$$

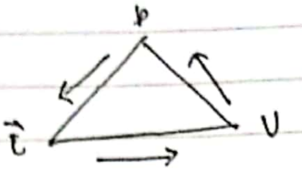
$$= \frac{q}{4\pi\varepsilon_0 r} \; ; \; b < r < c.$$

$$V_4 = -\int_\infty^r \frac{1}{4\pi\varepsilon_0} \, dr$$

$$V_4 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$$

* Hubungan antara $\vec{E}$, $\rho$ dan V

Dalam elektrostatika hubungan antara kuat medan dengan rapat muatan volume dan V skalar merupakan hubungan segitiga.




$$E = -\nabla V \qquad \nabla \times \vec{E} = 0$$

$$\nabla V = -\frac{\rho}{\varepsilon_0} \qquad \nabla \cdot \vec{E} = \frac{1}{\varepsilon_0}\rho$$

syarat elektrostatika.

$$\rho = \varepsilon \, \nabla \cdot E$$

Bentuk integralnya :

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r^2} \; ; \; dq = \rho \, d\tau$$

$$= \frac{1}{4\pi\varepsilon_0}\int \frac{\rho \, d\tau}{r^2}$$

$$V = -\int \vec{E} \cdot d\vec{p}$$

Hubungan V dengan $\rho$

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

Solusi hubungan $\Delta$ diatas

1.) Misal E diketahui, V & $\rho$ dapat dihitung

$$V = -\int E \, dp$$

$$\rho = \varepsilon_0 \nabla \cdot E$$

2.) Misal V diketahui E dan $\rho$ dapat dicari

$$E = -\nabla V$$

$$\rho = -\frac{1}{\varepsilon_0}\nabla^2 V$$

3.) Misal $\rho$ diketahui E dan V dapat dihitung

$$E = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho \, d\tau}{r^2}$$

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