Risnawati Hutapea (2213022079)

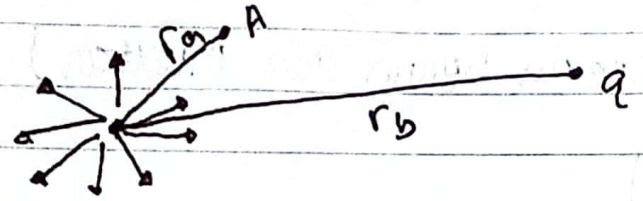
No.

Date

Catt. Pert 9 Kalisma

Usaha Dan Energi II

*) Usaha oleh muatan titik q



$W = \int_{(-)} \vec{F}\, dr$

(-) : negatif karena melawan muatan sumber

$W = \int_A^B \vec{F}\, d\vec{r}$

$= -q \int \vec{E}\, dl$

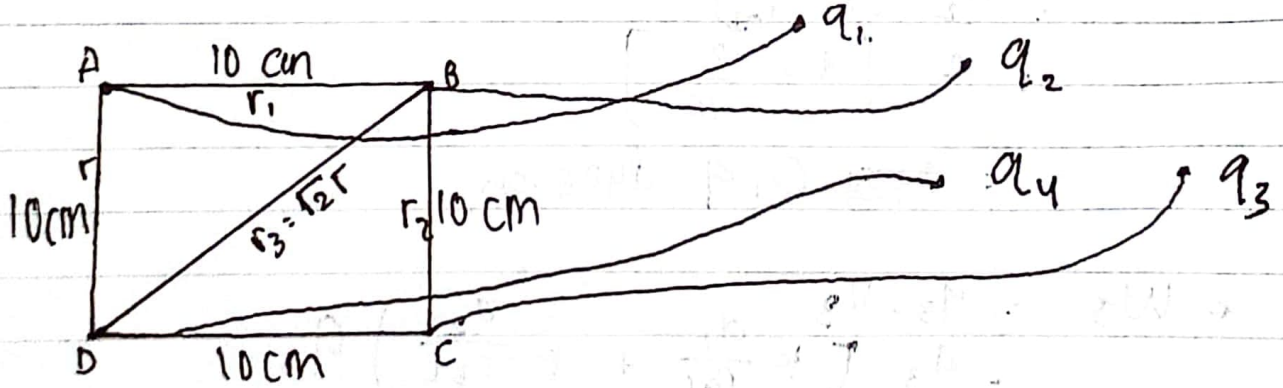
$= -q \left[\frac{1}{4\pi\varepsilon_0} - \frac{q}{r^2}\, dr \right]$

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

↳ diganti ● Q

$= Q\,[V]$

$= QV$



Dik : q_1 Pindah ke A = 0

q_2 Pindah ke B

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q_3 pindah ke C
q_4 pindah ke D
Muatan : 2 μC
Panjang sisi : 10 cm

Jb :

$W_1 = q_1 V_1 = 0$ (karena belum ada muatan)

$W_2 = q_2 V_2$
$= q_2 \left[k \frac{q_1}{r}\right]$
$= q_2 V_C$

$W_3 = q_3 V_3$
$= q_3 \left[k \frac{q_1}{r_1} + k \frac{q_2}{r_2}\right]$

$W_4 = q_4 V_4$
$= q_4 \left[k \frac{q_1}{r_1} + k \frac{q_2}{r_2} + k \frac{q_3}{r_3}\right]$

$W = \frac{1}{4\pi\varepsilon_0} \sum_{i=0}^{n} \sum_{j \neq i} \frac{q_i q_j}{r_{ij}}$

- $W_1 = 0$
- $W_2 = q_2 \cdot V_2$
  $= q_2 \left[F \frac{q_1}{r_{ab}}\right]$
  $= 2 \cdot \left[1 \cdot \frac{2}{10}\right]$
  $= 0,4$ dyne.cm

* $W_3 = q_3 \cdot V_3$
  $= q_3 \left[k \frac{q_1}{r_{ac}} + k \frac{q_2}{r_{bc}}\right] q_3$
  $= 2 \left[1 \cdot \frac{2}{10} + 1 \cdot \frac{2}{10\sqrt{2}}\right] = 0,683$ dyne.cm

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* $W_q = q_4 \cdot V_q$

$= q_4 \left[k\frac{q_1}{r_{ad}} + k\frac{q_2}{r_{bd}} + k\frac{q_3}{r_{ac}} \right]$

$= 2\left[1 \cdot \frac{2}{10\sqrt{2}} + 1 \cdot \frac{2}{10} + 1 \cdot \frac{2}{10} \right]$

$= 1{,}08$ dyne . cm

$$W = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}} \frac{q_i q_j}{r_{ij}}$$

$$W = \frac{1}{8\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{q_i q_j}{r_{ij}}$$

$$W = \frac{1}{2} \sum_{i=1}^{n} q_i V$$

- Energi dari muatan distribusi kontinu

Garis → $\frac{1}{2} \int \lambda V \, dl$

permukaan → $\frac{1}{2} \int \sigma V \, dA$

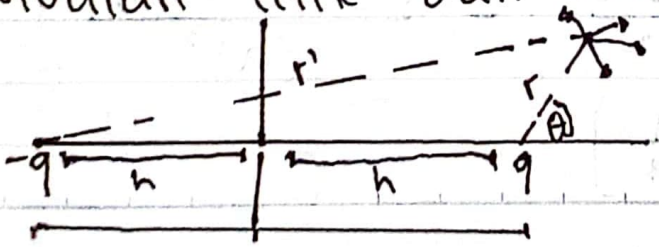
volume → $\frac{1}{2} \int \rho V \, d\tau$

$$W = \frac{\varepsilon_0}{2} \int_{\text{surface}} E^2 \, d\tau$$

Bab 3. Metoda Penentuan Potensial

Metoda bayangan

1. Muatan titik dan batang konduktor



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$$P = \frac{1}{4\pi\varepsilon_0}\,\frac{q}{r}$$

$$= \frac{q}{4\pi\varepsilon_0 r'}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{r'}\right]$$

$$r' = \sqrt{(2h)^2 + (r)^2}$$

$$= \sqrt{4h^2 + 4hr\cos\theta + r^2}$$

$$V_p = V(r,\theta) = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{(r^2 + 4h^2 + 4hr\cos\theta)^{1/2}}\right]$$

Turunkan terhadap r

$$E_r = -\frac{\partial V}{\partial r} = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r^2} - \frac{r + 2h\cos\theta}{r'^3}\right]$$

Turunkan terhadap θ

$$E_\theta = -\frac{1}{r}\frac{\partial V}{\partial \theta} = \frac{q}{4\pi\varepsilon_0}\left[\frac{2h\sin\theta}{r'^3}\right]$$

Turunkan terhadap z

$$E_z = E_r\cos\theta - E_\theta\sin\theta$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{\cos\theta}{r^2} - \frac{r\cos\theta + 2h}{(r^2 + 4h^2 + 4hr\cos\theta)^{3/2}}\right]$$

Jika $r = r' = a$

$$E_z = \frac{q}{4\pi\varepsilon_0}\left[\frac{\cos\theta}{r^2} - \frac{r\cos\theta + 2h}{(a)^3}\right]$$

$$= \frac{-q}{4\pi\varepsilon_0}\left(\frac{2h}{a^3}\right)$$

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$$= \frac{-q}{2\pi\varepsilon_0} \cdot \left[\frac{h}{a^3}\right]$$

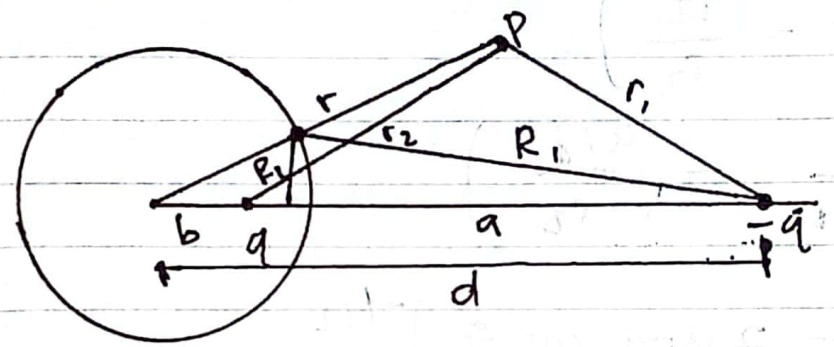
$$= \frac{1}{\varepsilon_0}\sigma(a)$$

$$\iint \sigma\, dA = -hq \int_0^\infty \frac{x}{a^3}\, dx$$

$$= -hq \int_0^\infty (a\, da)$$

$$= -q \text{ muatan bayangan}$$

2. Muatan titik dengan bola konduktor



$V = 0$

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{R_1} - \frac{q_2}{R_2}\right) = 0$$

$$R_1^2 = a^2 + d^2 - 2ad\cos\theta$$

$$R_2^2 = a^2 + b^2 - 2ab\cos\theta$$

Untuk $V = 0$, maka

$$\frac{q_1}{R_1} = \frac{q_2}{R_2} \rightarrow \frac{q_1^2}{q_2^2} = \frac{R_1^2}{R_2^2} = \frac{a^2 + d^2 - 2ad\cos\theta}{a^2 + b^2 - 2ab\cos\theta}$$

$$\left(\frac{q_1}{q_2}\right)^2 + \left(\frac{R_1}{R_2}\right)^2 = \frac{d}{b}\left[\frac{q^2/a^2 + d - 2ad\cos\theta}{q^2/a^2 + b - 2ab\cos\theta}\right]$$

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1) $q^2 = db$

2) $\left(\frac{q_1}{q_2}\right)^c = \frac{d}{b}$ karna $d > b$ dan $q_1 > q_2$

$\frac{q_1^2}{q_2^2} = \frac{d}{b} \Rightarrow -q_2 = 1\sqrt{\frac{b}{d}} \cdot q_1$, untuk $b = \frac{q^2}{d}$

$$q_2 = -\frac{q}{d} * q_1$$

Jadi $V(r, \theta) = V_p$

$$V_p = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} - \frac{q_2}{r_2}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} - \frac{q/d}{r_2}\right)$$

$r_1 = (r^2 + d^2 - 2ard\cos\theta)^{-1/2}$

$r_2 = (r^2 + b^2 - 2arb\cos\theta)^{1/2}$

- $V_p = \frac{q_1}{4\pi\varepsilon_0}\left(\frac{1}{(r^2 + d^2 - 2rd\cos\theta)^{1/2}} - \frac{q/d}{\left(r^2 + \frac{q^4}{d^2}\left(\frac{d^2}{d}\cos\theta\right)\right)^{1/2}}\right)$

$E_r = -\frac{2V}{2r}$

$E\theta = -\frac{1}{r}\frac{2V}{2\theta}$

u/ → permukaan bola, $r = a$

$$E_r = -\frac{q_1}{4\pi\varepsilon_0}\left[\frac{-(a - d\cos\theta)}{(a^2 + d^2 - 2ad\cos\theta)^{1/2}} + \frac{\frac{q}{d}(a - q^2/d\cos\theta)}{(a^2 + \frac{q^4}{d^2} - 2q/\frac{q^2}{d}(\cos\theta)^{3/2}} + \frac{d^2/d(1 - q/d\cos\theta)}{a^5/d^3(a^2 + q^2 - 2ad\cos\theta)^{3/2}} + \frac{d^2/4(1 - \frac{q}{d}\cos\theta)}{(q^2 + d^2 - 2ad\cos\theta)^{3/2}}\right]$$

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$$E_r = \frac{-q_1}{4\pi\varepsilon_0}\left[\frac{-(a-d\cos\theta)+d^2/a\,(1-a/d\cos\theta)}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right.$$

$$E_r = \frac{-q_1}{4\pi\varepsilon_0}\left(\frac{d^2-a^2}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right)$$

Dengan cara yang sama

$E_\theta = 0$

Disini terjadi pergerakan listrik D

$D = \varepsilon_0 E \rightarrow = \sigma_F = \sigma$

$$\sigma = \varepsilon_0 E_r$$

$$\sigma = \frac{-q_1}{4\pi a}\left(\frac{d^2-a^2}{(a^2+d^2-2ad\cos\theta)^{3/2}}\right)$$

σ : Muatan Induksi / satuan luas pada bola konductor

F : Gaya antara bola dengan q_1

$$F = -\frac{1}{4\pi\varepsilon_0}\,\frac{q_1 \cdot q_2}{(d-b)^2}$$

$$= \frac{-1}{4\pi\varepsilon_0}\,\frac{a\,q_1^2}{4(a-d)^2}$$