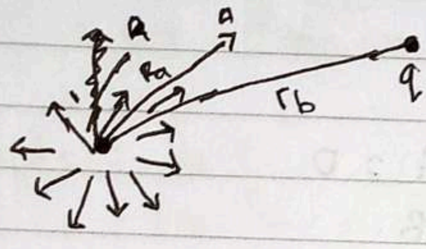
Kelistrikan dan Kemagnetan

USAHA DAN ENERGI

* Usaha oleh Muatan Listrik?



$W = \int -\vec{F}\, d\vec{r}$

(-) negatif karena melawan muatan sumber.

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

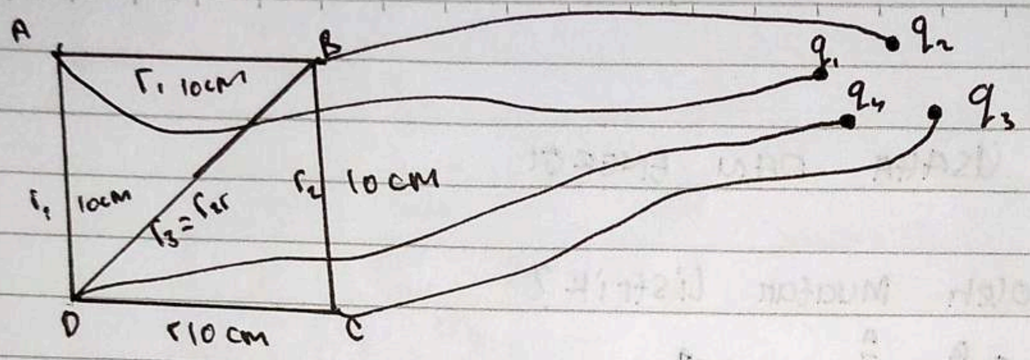
$= -q \int \vec{E}\, dl$

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

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

$= Q\ [V]$

$= QV$



Diketahui : q_1 Pindah ke A = 0
q_2 — 11 — B
q_3 — 11 — C
q_4 — 11 — D
Muatan : 2 Mc
Panjang = 10 cm

Jawab :

$W_1 = q_1 V_1 = 0$ (karena belum ada Massa).

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

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

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

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

No.

Date . .

$W_1 = 0$

$W_2 = V_2 \cdot q_2$

$= k \dfrac{q_1}{r_{ab}} \cdot q_2$

$= 1 \cdot \dfrac{2}{10} \cdot 2$

$= 0,4$ dyne.cm

$W_3 = V_3 \, q_3$

$= \left(k \dfrac{q_1}{r_{ac}} + k \dfrac{q_1}{r_{bc}}\right) q_3$

$= \left(1 \dfrac{2}{10} + 1 \dfrac{2}{10\sqrt{2}}\right) 2$

$= 0,683$ dyne. cm

$W_4 = V_4 \cdot q_4$

$= \left(k \dfrac{q_1}{r_{ad}} + \dfrac{q_2}{r_{bd}} + \dfrac{q_3}{r_{ac}}\right)$

$= \left(1 + \dfrac{2}{10\sqrt{2}} + 1 \dfrac{2}{10} + 1 \dfrac{2}{10}\right) 2$

$= 1,08$ dyne. cm

$$\left.\begin{aligned} W &= \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}} \frac{q_i q_j}{r_{ij}} \\ W &= \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{q_i q_j}{r_{ij}} \end{aligned}\right\} W = \frac{1}{2} \sum_{i=1}^{n} q V$$

No.

Date . .

* Energi dari Muatan distribusi kontinu

Garis $\rightarrow \frac{1}{2} \int \lambda v \, dl$

Permukaan $\rightarrow \frac{1}{2} \int \sigma v \, d\theta$

Volume $\rightarrow \frac{1}{2} \int \rho v \, d\sigma$

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

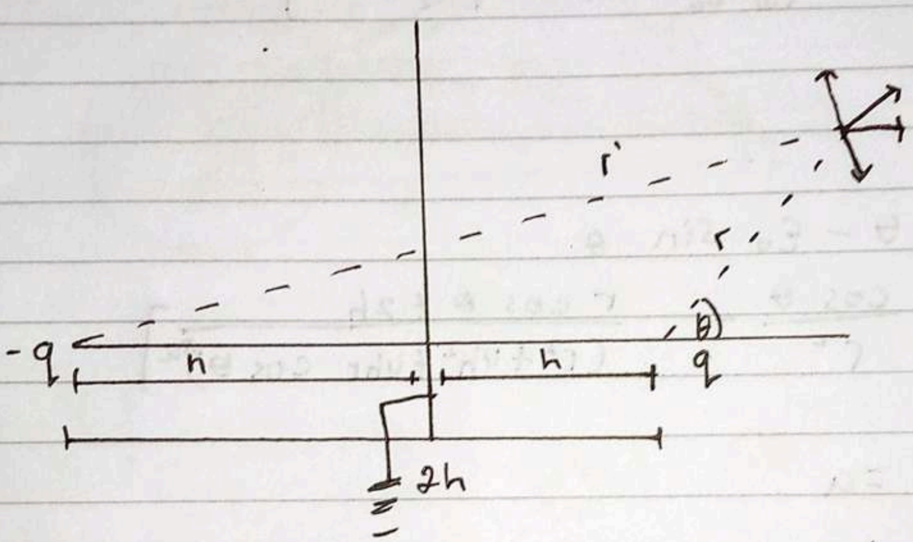
No.

Date

BAB 3. Metoda Penentuan Potensial

Metode Bayangan.

1. Muatan titik dan batang konduktor



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

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

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

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

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

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

tentukan terhadap θ

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

terhadap z

$$E_z = E_r\cos\theta - \varepsilon_0\sin\theta$$

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

AB, $r = r' = a$

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

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

$$= \frac{-q}{2V\varepsilon_0}\left(\frac{h}{q^3}\right) \quad z'$$

$$= \frac{1}{\varepsilon_0}\sigma_{(a)} \int \to \iint r\,dA \quad = -hq\int_0^\infty \frac{x}{a^3}\,dr$$

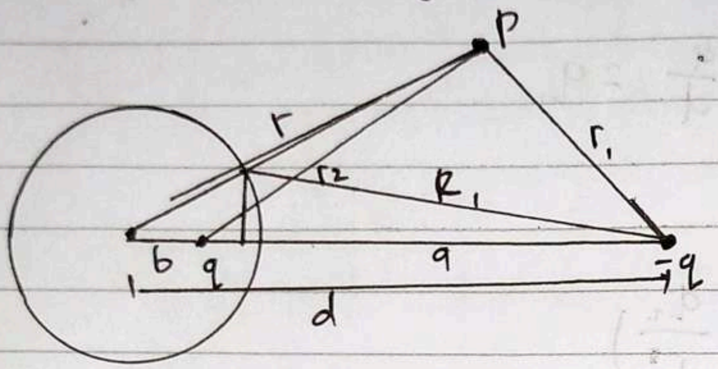
$$= -hq\int_0^\infty (ada)$$

$= -q$ muata

No.

Date

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 $V = 0$ muatan

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

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

1. $a^2 = db$

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

No.

Date

$$\frac{q_1^2}{q_2^2} = \frac{d}{b} = -q_2 = +\sqrt{\frac{b}{d}} \cdot q_1 \quad \text{untuk} \quad b = \frac{q^2}{d}$$

$$= q^2 = -\frac{a}{d} = q_1$$

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

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

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_2} - \frac{a/d}{r^2}\right)$$

$$r_1 = (r^2 + d^2 - 2 \quad ard \quad \cos\theta)^{1/2}$$
$$r_2 = (r^2 + b^2 - 2ar\cancel{b} \cos\theta)^{1/2}$$

$$V_p = \frac{q_1}{4\pi\varepsilon_0}\left(\frac{1}{(r^2 + d^2 - 2rd \cos\theta)^{1/2}} - \frac{a/d}{(r^2 + \frac{q_4}{d^2}(d^2/d \cos\theta)^{1/2}}\right.$$

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

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

Permukaan bol $r = a$

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

$$+ \frac{\frac{d^2}{d}(1 - \frac{a}{d}\cos\theta)}{a^3/d^3(d^2 + q^2 - 2ad\cos\theta)^{3/2}} + \frac{d^2/a(1 - \frac{d}{d}\cos\theta}{(q^2 + d^2 - 2ad\cos\theta)^{1/2}}$$

No.

Date

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

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

$E_\theta = 0$

Disini terjadi pergerak limit →

$D = \varepsilon_0 E \rightarrow = r_f = 0$

$r = \varepsilon_0 E_r$

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

σ = Muatan induksi / satu luas pd bola koordinat

F = cara antar bola daya q_1

$$F = -\frac{1}{4\pi\varepsilon_0}\frac{q_1 d_2}{(d-b)^2}$$

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