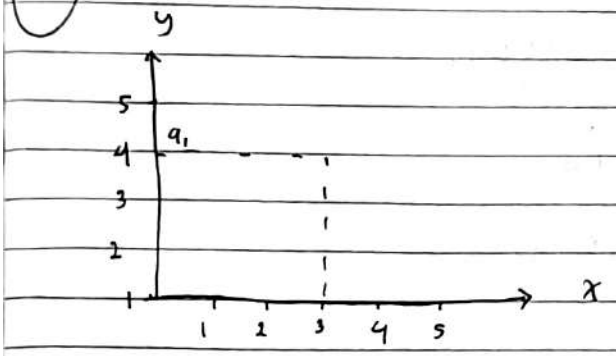
Nama : Rizki Mirantika
NPM : 2423022001
Matkul : Elektrodinamika

1. Gaya, medan, potensial, usaha dan energi oleh muatan listrik
empat buah muatan benda para posisi q_1 (0, 4) m, $-q_2$ (0, 0)
q_3 (3, 4) m dan q_4 (3, 0) m
a. Hitung gaya listrik yg dialami oleh muatan q_2!
b. Hitung medan listrik pada muatan q_2!
c. Hitung potensial pada muatan q_4
d. Berapa besarnya usaha untuk memindahkan ke empat muatan
dari jarak tak hingga

Jawab

a.



gaya q_1 ke q_2 $r = 4$ m

$$\vec{F}_{21} = k \frac{q_1 q_2}{r^2}$$

$$= k \frac{q_1 q_2}{4^2}$$

$$= k \frac{q_1 q_2}{16}$$

gaya q_3 ke q_2 $r = 5$ m

$$\vec{F}_{32} = k \frac{q_1 q_2}{r^2}$$

$$= k \frac{q_1 q_2}{5^2}$$

$$= k \frac{q_1 q_2}{25}$$

gaya q_4 ke q_2 $r = 3$m

$$F_{q_2} = k \frac{q_1 q_2}{r^2}$$

$$= k \frac{q_1 q_2}{3^2}$$

$$= k \frac{q_1 \cdot q_2}{9}$$

$$F_{tot} = F_{21} + F_{32} + F_{42}$$

$$= k \frac{q_1 q_2}{16} \hat{j} + k \frac{q_1 q_2}{25} + \frac{k q_1 q_2}{9} \hat{i}$$

KKY

(b) Medan listrik q_1

medan q_{21} - $r = 4$

$$E_{q_{21}} = \frac{k q_1}{r_{21}^2} \cdot \hat{r}_{21}$$

$$= k \frac{q_1}{4^2} \hat{i}$$

$$= k \frac{q_1}{16} (i)$$

medan q_{23} $r = 5$ atau $\sqrt{3^2+4^2}$

$$E_{q_{23}} = k \frac{q_3}{r_{23}^2} \hat{r}_{23}$$

$$= k \frac{q_3}{(\sqrt{3^2+4^2})} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right)$$

$$= k \frac{q_3}{\sqrt{3^2+4^2}} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right)$$

$$= k \frac{q_3}{25} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right)$$

medan q_{24} $r = 3$

$$E_{q_{24}} = k \frac{q_4}{r_{24}^2} \hat{r}_{24}$$

$$= k \frac{q_4}{3^2} \hat{i}$$

$$= k \frac{q_4}{9} \hat{i}$$

$$E_{tot} = E_{q_{21}} + E_{q_{23}} + E_{q_{24}}$$

$$= k \frac{q_1}{16} (i) + k \frac{q_2}{25} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right) + \frac{q_4}{9} \hat{i})$$

$$= k \left[\left(\frac{3q_3}{125} + \frac{q_4}{9}\right)\hat{i} + \left(\frac{q_1}{16} + \frac{4q_3}{125}\right)\hat{j} \right]$$

(c) Potensial q_4

$$V_{q_1} = k \frac{q_1}{r_{q_1}} + q_1$$

$$= k \frac{q_1}{\sqrt{3^2+4^2}} \left(3\hat{i} + 4\hat{j}\right)$$

$$= k \frac{q_1}{5} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right)$$

$$V_{q_2} = \frac{k q_2}{r_{q_2}} \hat{r}_{q_2}$$

$$= k \frac{q_2}{3} \hat{i}$$

$$V_{q_3} = k \frac{q_3}{r_{q_3}} \hat{r}_{q_3}$$

$$= k \frac{q_3}{4} \hat{i}$$

$$V_{tot} = V_{q_1} + V_{q_2} + V_{q_3}$$

$$= k \frac{q_1}{5} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right) + k \frac{q_2}{3} \hat{i} + k \frac{q_3}{4} \hat{i}$$

$$= k \left[\left(\frac{3q_1}{25} + \frac{q_2}{3}\right)\hat{i} + \left[\frac{4q_1}{25} + \frac{q_3}{4}\right)\hat{j} \right]$$

(d) Besarnya untuk usaha memindahkan muatan

$$U = k \frac{q_1 q_2}{r} \hat{r}$$

$$U_{12} = k \frac{q_1 q_2}{r_{12}} \hat{r}_{12} = k \frac{q_1 q_2}{4} (\hat{j})$$

$$U_{13} = k \frac{q_1 q_3}{r_{13}} \hat{r}_{13}$$

$$= k \frac{q_1 q_3}{3} (\hat{i})$$

$$U_{14} = k \frac{q_1 q_4}{r_{14}} \hat{r}_{14}$$

$$= k \frac{q_1 q_4}{\sqrt{3^2+4^2}} \left(\frac{3\hat{i} + 4\hat{j}}{5}\right)$$

$$U_{23} = k \frac{q_2 q_3}{q_{23}} \hat{r}_{23}$$

$$= k \frac{q_2 q_3}{\sqrt{3^2+4^2}} (3\hat{i} + 4\hat{j})$$

$$U_{24} = k \frac{q_2 q_4}{r_{24}} \hat{r}_{24}$$

$$= k q_2 q_4 \hat{i}$$

$$U_{34} = k \frac{q_3 q_4}{r_{34}} \hat{j}$$

$$= k \frac{q_2 q_4}{4} \hat{j}$$

$$U_{total} = U_{12} + U_{13} + U_{14} + U_{23} + U_{24} + U_{34}$$

$$= k \left[\frac{q_1 q_2}{3} + \frac{3 q_1 q_2}{25} + \frac{3 q_1 q_4}{25} + \frac{q_2 q_4}{3} + q_3 q_4/4)\hat{i} + \left(q_1 q_2/4 + 4\, q_1 q_2/25 + 4 q_2 \cdot q_3\right)\hat{j} \right]$$

KKY

2. Medan potensial usaha dan energi oleh muatan kontinue.

e. Hitung medan listrik sejauh z diatas kawat lurus panjang sekali dg rapat muatan per satuan panjang λ.

f. sebuah silinder pejal panjang sekali dengan jari: silinder R, rapat muatannya $\rho = kr$, hitung medan listrik di dalam ($r < R$), di permukaan ($r > R$) dan di luar silinder ($r > R$)

Permukaan gauss

g. Hitung potensial listrik sejauh z diatas pusat lingkaran oleh muatan kontinue r pada plat logam tipis berbentuk lingkaran dg jari: R!

H. Sebuah bola konduktor dg muatan permukaan q, jari: nya R, hitung berapa energi yg tersimpan dalam bola tsb!.

Jawaban.

(e) $\oint E\,dA = \frac{q_{in}}{\varepsilon_0}$

Rapat muatan

$Q_{in} = \lambda \cdot L$

$\oint E\,dA = E(2\pi rl)$

$E(2\pi rl) = \frac{\lambda l}{\varepsilon_0}$

$E = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 z}$

(f) di dalam silinder ($r < R$)

$\oiint \vec{E}\,da = \frac{Q_{in}}{\varepsilon_0} = \rho\,dv$

$\vec{E}\,2\pi rl = \frac{1}{\varepsilon_0}\int_0^R \int_0^{2\pi}\int_0^l (kr)\,r\,dr\,d\varphi\,dz$

$= \frac{2\pi lk}{\varepsilon_0}\int_0^R r^2\,dr$

$\vec{E}\,2\pi rl = \frac{2\pi lk}{\varepsilon_0}\left[\frac{1}{3}r^3\right]_0^R$

$\vec{E}\,2\pi Rl = \frac{2\pi lk R^3}{3\varepsilon_0}$

$E = \frac{kR^2}{3\varepsilon_0}$

di luar silinder

$Q_{total} = \int_0^R \rho\,dv$

$= \int_0^R kr\,(2\pi rl)\,dr$

$= 2\pi Rl \int_0^R r^2\,dr$

$= 2\pi kl\,(\frac{1}{3}r^3)_0^R$

$= \frac{2\pi klR^3}{3}$

$r > R$

$\oint E\,da = \frac{Q_{total}}{3\varepsilon_0}$

$\vec{E} = \frac{kR^3}{3\varepsilon_0 r}$

KIKY

(9.) Elemen luas

$dA = 2\pi r' dr'$

Elemen muatan

$da = \delta . dA = \delta 2\pi r' dr'$

jarak

$|\vec{r} - \vec{r}'| = \sqrt{r'^2 + z^2}$

Potensial muatan

$dV = \frac{1}{4\pi\varepsilon_0} \frac{da}{\sqrt{r'^2 + z^2}}$

$= \frac{\delta}{2\varepsilon_0} \frac{r'}{\sqrt{r'^2 + z^2}} dr'$

$V(z) = \int_0^R dV$

$= \frac{\delta}{2\varepsilon_0} \int_0^R \frac{r'}{\sqrt{r'^2 + z^2}} dr'$

$= \frac{\delta}{2\varepsilon_0} \int_{z^2}^{R^2+z^2} \frac{1}{2\sqrt{u}} du$

$= \frac{\delta}{2\varepsilon_0} \int_{z^2}^{R^2+z^2} u^{-1/2} du$

$= \frac{\delta}{4\varepsilon_0} (2\sqrt{u})^{R^2+z^2} = \frac{\delta}{2\varepsilon_0} \left(\sqrt{R^2+z^2} - z\right)$

(H.) Energi total

$U = \frac{1}{2} \int \rho(\vec{r}) V(\vec{r}) d^3r$

$U = \frac{1}{2} qV$

$V = \frac{1}{4\pi\varepsilon_0} \frac{q}{R}$

maka

$U = \frac{1}{2} q \cdot V$

$= \frac{1}{2} q \left(\frac{1}{4\pi\varepsilon_0}\right) \cdot \frac{q}{r}$

$= \frac{1}{8\pi\varepsilon_0} \cdot \frac{q_2}{r}$

$= \frac{q^2}{8\pi\varepsilon_0 R}$

KIKY