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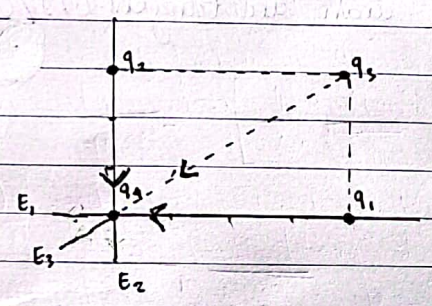
Kelas : B

1) Empat partikel bermuatan listrik terdistribusi sebagai berikut :
$q_1(4,0) = 2$
$q_2(0,3) = 5$
$q_3(4,3) = 10$
$q_4(0,0) = -1$
Tentukan : Medan listrik pada posisi (0,0), dimana jarak dalam cm, $k = 1$ dyne./cm^2/stat c^2. Hitung :

penyelesaian

1)



b) $\vec{E_1} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r_1^2} \hat{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2}{16} (\hat{i})$

$\vec{E_2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{5}{9} (\hat{j})$

$\vec{E_3} = \frac{1}{4\pi\varepsilon_0} \frac{10}{25} \left(\frac{4\hat{i} + 3\hat{j}}{5}\right) = \frac{1}{4\pi\varepsilon_0} \left(\frac{40\hat{i} + 30\hat{j}}{125}\right)$

$\vec{E_4} = \frac{1}{4\pi\varepsilon_0} \left[\left(\frac{5}{9} + \frac{30}{125}\right)(\hat{j}) + \left(\frac{2}{16} + \frac{40}{125}\right)(\hat{i})\right]$

$\vec{E_4} = \frac{1}{4\pi\varepsilon_0} \sqrt{(0,79)^2 + (0,495)^2}$

$\vec{E_4} = 9.10^9 \times 0,90$
$\vec{E_4} = 8,16 \times 10^8$ N/C

(a) Gaya Coulomb pada q_4

$$\vec{F} = q_4 . k \left\{ \frac{q_2}{r_{02}^2} \hat{r}_{02} + \frac{q_3}{r_{03}^2} \hat{r}_{03} + \frac{q_1}{r_{01}^2} \hat{r}_{01} \right\}$$

$$\vec{F} = -1 . 9\times10^9 \left\{ \frac{5}{9}(-\hat{j}) + \frac{10}{25}\left(\frac{-4\hat{i}-3\hat{j}}{5}\right) + \frac{2}{16}(-\hat{i}) \right\}$$

$$\vec{F} = 9\times10^9 \left\{ \frac{5}{9}(\hat{j}) + \frac{10}{25}\left(\frac{4\hat{i}+3\hat{j}}{5}\right) + \frac{2}{16}(\hat{i}) \right\}$$

$$\vec{F} = 9\times10^9 \left\{ \left(\frac{2}{16} + \frac{40}{125}\right)(\hat{i}) + \left(\frac{5}{9} + \frac{30}{125}\right)(\hat{j}) \right\}$$

$$\vec{F} = 9\times10^9 \left(0{,}495\,\hat{i} + 0{,}79\,\hat{j}\right)$$

$$\vec{F} = 9\times10^9 \sqrt{(0{,}495)^2 + (0{,}79)^2}$$ dalam arah arc tangen $(0{,}79/0{,}495)$

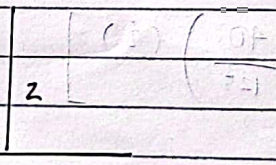
(c) $$V = \frac{kq_2}{r_2} + \frac{kq_3}{r_3} + \frac{kq_1}{r_1}$$

$$V = 9.10^9 \left(\frac{5}{9} + \frac{10}{25} + \frac{2}{16}\right)$$

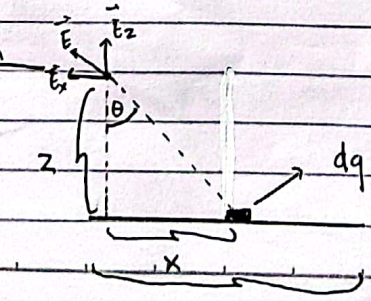
$$V = 9.10^9 \left(1{,}08\right)$$

$$V = 9{,}72 \times 10^9$$

(2) Sebuah kawat lurus panjangnya a, membawa muatan seragam λ. Hitung medan listrik di titik P di atas kawat yg berjarak z ditengah-tengah kawat.



penyelesaian



$$\vec{E} = \vec{E}_z + \vec{E}_x$$

$$\vec{E}_z = \frac{1}{4\pi\varepsilon_0}\int_0^a \frac{dq}{r^2} = \frac{1}{4\pi\varepsilon_0}\int_0^a \frac{\lambda\, dx}{r^2}\cos\theta$$

$$\Rightarrow \cos\theta = \frac{z}{r}$$

$$\vec{E}_z = \frac{1}{4\pi\varepsilon_0}\int_0^a \frac{z\lambda\, dx}{r^2} = \frac{1}{4\pi\varepsilon_0}\int_0^a \frac{z\lambda\, dx}{(z^2+x^2)^{3/2}}$$

$$= \frac{z\lambda}{4\pi\varepsilon_0}\int_0^a \frac{dx}{(z^2+x^2)^{1/2}}$$

$$\Rightarrow \int_0^a \frac{dx}{(z^2+x^2)^{3/2}} = \frac{1}{z^2}\frac{x}{\sqrt{z^2+x^2}}\Bigg|_0^a$$

$$\vec{E}_z = \frac{1}{4\pi\varepsilon_0}\lambda z\left[\frac{1}{z^2}\frac{x}{\sqrt{z^2+x^2}}\right]_0^a$$

$$\vec{E}_z = \frac{\lambda z}{4\pi\varepsilon_0}\cdot\frac{a}{z^2\sqrt{z^2+x^2}}$$

$$\vec{E}_z = \frac{\lambda}{4\pi\varepsilon_0}\cdot\frac{a}{z\sqrt{z^2+x^2}}$$

$$\vec{E}_x = -\frac{1}{4\pi\varepsilon_0}\int_0^a \frac{\lambda\, dx}{r^2}\sin\theta$$

$$= \frac{-\lambda}{4\pi\varepsilon_0}\int_0^a \frac{x\, dx}{(z^2+x^2)^{1/2}}$$

$$= -\frac{\lambda}{4\pi\varepsilon_0}\cdot\frac{1}{2}\left[-2\,\frac{1}{(z^2+x^2)^{1/2}}\right]_0^a$$

$$= \frac{-\lambda}{4\pi\varepsilon_0}\left[-\left(\frac{1}{\sqrt{z^2+x^2}} - \frac{1}{z}\right)\right]$$

$$\vec{E}_x = \frac{-\lambda}{4\pi\varepsilon_0}\left[\frac{1}{z} - \frac{1}{\sqrt{z^2+x^2}}\right]$$

jadi $\vec{E} = \vec{E} + \vec{E}_x$

$$= \frac{\lambda}{4\pi\varepsilon_0} \cdot \frac{a}{z\sqrt{z^2+x^2}} + \left(\frac{-\lambda}{4\pi\varepsilon_0} \left[\frac{1}{z} - \frac{1}{\sqrt{z^2+x^2}} \right] \right)$$

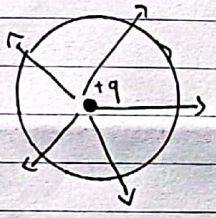
4) Hukum gauss menyatakan bahwa fluks medan listrik yg keluar dari suatu permukaan tertutup sembarang yg melingkupi muatan-muatan $q_1, q_2, \ldots$

Hukum gauss → untuk memudahkan menghitung medan listrik oleh objek 2D / 3D (Bola, silinder, bidang)

$$\oint E \cdot dA = \frac{q_{enc}}{\varepsilon_0}$$

q_{enc} → muatan listrik yg terkandung di dalam permukaan tertutup.

contoh :



$$\phi = \frac{q}{\varepsilon_0}$$

medan listrik dari muatan listrik akan menembus bola (menembus keluar).