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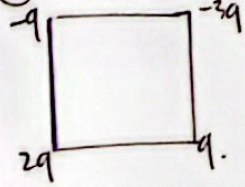
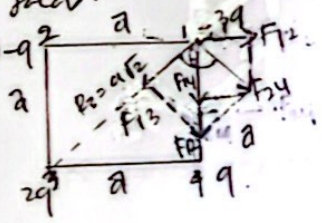
(1.) Ada tiga muatan seperti pada gambar berikut:

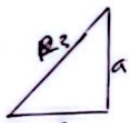


a. Gambar gaya-gaya pada muatan 3q.
b. Hitung besar gaya tersebut.
c. Hitung medan listrik pada gaya tersebut
d. Hitung besar medan listrik pada titik tersebut.
e. Hitung potensial listrik pada titik tersebut.

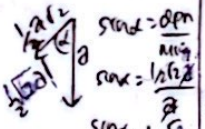
Jawab:

(a.)





$R_3 = \sqrt{a^2+a^2}$
$R_3 = \sqrt{2a^2}$
$R_3 = a\sqrt{2}$



sin α = depan / miring
sin α = 1/2 a√2 / a
sin α = 1/2 √2

(c.) $E_{12} = \frac{kq_2}{R_2^2} = \frac{k(q)}{a^2} = \frac{kq}{a^2}$

$E_{13} = \frac{kq_3}{R_3^2} = \frac{k(2q)}{(a\sqrt{2})^2} = \frac{2kq}{2a^2} = \frac{kq}{a^2}$

α = 45°
θ = 2α
θ = 90°

$E_{14} = \frac{kq_4}{r_4^2} = \frac{k(q)}{a^2} = \frac{kq}{a^2}$

besar medan listrik E_{24}

$E_{24} = \sqrt{E_{12}^2 + E_{14}^2}$

$E_{24} = \frac{kq_2}{r_{12}^2} = \frac{k(q)}{a^2} = \frac{kq}{a^2}$

$E_{24} = \frac{kq_4}{r_{14}^2} = \frac{kq}{a^2}$

misal $E = \frac{kq}{a^2}$ maka:

$E_{12} = E$ dan $E_{14} = E$

$E_{13} = E$, $E_{24} = E$

maka $E_{24} = \sqrt{E_{12}^2 + E_{14}^2}$

$E_{24} = \sqrt{(E)^2 + (E)^2}$

$E_{24} = \sqrt{E^2 + E^2} = \sqrt{2E^2}$

$E_{24} = E\sqrt{2}$

$E_{24} = \frac{kq}{a^2}\sqrt{2}$

(d) maka besar medan listrik resultan:

$\Sigma E = \sqrt{(E_{24})^2 + (E_{13})^2 + 2(E_{24})(E_{13})\cos\theta}$

$\Sigma E = \sqrt{(E)^2 + (E)^2 + 2(E)(E)\cos 90^\circ} = \sqrt{2E^2}$

$\Sigma E = \frac{kq}{a^2}\sqrt{2}$

(b) Besar medan listrik pada titik 3q.

$F_{12} = \frac{kq_1q_2}{r_{12}^2} = \frac{k(3q)(q)}{a^2}$

$F_{12} = \frac{3kq^2}{a^2}$

$F_{14} = \frac{kq_1q_4}{r_{14}^2} = \frac{k(3q)(q)}{a^2}$

$F_{14} = \frac{3kq^2}{a^2}$

misal $\frac{3kq^2}{a^2} = F$ maka: $F_{12} = F$. $F_{14} = F$

$F_{24} = \sqrt{F_{12}^2 + F_{14}^2} = \sqrt{F^2 + (F)^2} = \sqrt{2F}$

$F_{24} = F\sqrt{2} = \frac{3kq^2}{a^2}\sqrt{2}$

$F_{24} = \frac{3kq^2}{a^2}\sqrt{2}$

maka $F_{24} = \sqrt{2}F$

$F_{13} = \frac{kq_1q_3}{(r_{13})^2} = \frac{k(3q)(2q)}{(a\sqrt{2})^2}$

$F_{13} = \frac{6kq^2}{2a^2} = \frac{3kq^2}{a^2}$

$F_{13} = F_{12} = F$

maka besar gaya resultan:

$\Sigma F = \sqrt{(F_{13})^2 + (F_{24})^2 + 2F_{13}F_{24}\cos\theta}$

$\Sigma F = \sqrt{(F)^2 + (\sqrt{2}F)^2 + 2(F)(\sqrt{2}F)\cos 90^\circ}$

$\Sigma F = \sqrt{F^2 + 2F^2} = \sqrt{3F^2}$

$\Sigma F = F\sqrt{3}$

$\Sigma F = \frac{3kq^2}{a^2}$

5) Potensial listrik pada titik tersebut:

$$V_{P1} = V_{P11} + V_{P12} + V_{P13} + V_{P14}$$

$V_{P11} = 0$ J

$$V_{P12} = \frac{kq_1q_2}{R_{12}} = \frac{k(-3q)(-q)}{a} = \frac{3kq^2}{a}$$

$$V_{P13} = \frac{kq_1q_3}{R_{13}} = \frac{k(-3q)(2q)}{a\sqrt{2}} = \frac{-6kq^2}{a\sqrt{2}}$$

$$V_{P14} = \frac{kq_1q_4}{R_{14}} = \frac{k(-3q)(q)}{a} = \frac{-3kq^2}{a}$$

Maka potensial listrik di titik $-3q$ adalah:

$$V_{P1} = 0 + \frac{3kq^2}{a} - \frac{6kq^2}{a\sqrt{2}} - \frac{3kq^2}{a}$$

$$V_{P1} = \frac{-6kq^2}{a\sqrt{2}}$$

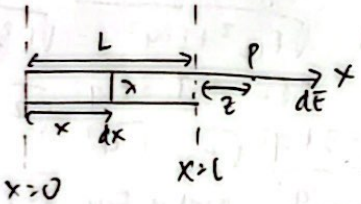
7. Sebuah batang panjangnya L, rapat muatan persatuan panjang adalah λ. Hitung:

a. Kuat medan listrik di titik P yg berjarak z dr sumbu x.
b. Kuat medan listrik di titik P yg berjarak z dr batang-tegak lurus.

Jawab:

$$\frac{Q}{L} = \lambda$$

a.



$E = \int dE$

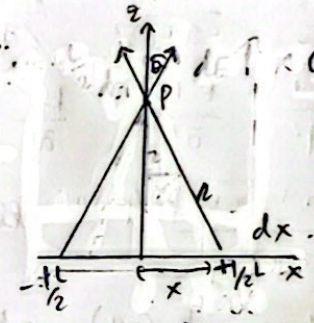
$dE = k\frac{dq}{r^2} \rightarrow dq = \lambda dx \quad r = L+z-x$

$dE = k\frac{\lambda dx}{(L+z-x)^2}$

$dE = \frac{k\lambda dx}{(L+z-x)^2}$

$E = k\lambda \int_0^L \frac{dx}{(L+z-x)^2}$

b.



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

$r = \sqrt{z^2+x^2}$

x berjarak dari: 0 hingga

$$E = \frac{1}{4\pi\varepsilon_0}\int_0^{1/2L} \frac{2\lambda z}{(z^2+x^2)^{3/2}}dx$$

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

$$E = \frac{1}{4\pi\varepsilon_0}\frac{z\lambda \frac{1}{2}L}{z\sqrt{z^2+(\frac{1}{2}L)^2}}$$

untuk $(z \gg L)$ $E =$

$$E \cong \frac{1}{4\pi\varepsilon_0}\frac{2\lambda(\frac{1}{2}L)}{z^2}$$

$$E \cong \frac{1}{4\pi\varepsilon_0}\frac{\lambda L}{z^2}$$

Pada $L \rightarrow \infty$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{\lambda}{z}$$

(3) Hitung medan listrik pada bola konduktor dengan rapat muatan σ dan jari-jari R.

Jawab:

$\Phi = \frac{Q}{\varepsilon_0}$

$\Phi = \frac{\sigma . V}{\varepsilon_0}$ dengan $V_{bola} = \frac{4}{3}\pi R^3$

$Q = \sigma V$

$\varepsilon_0 \Phi = \sigma V$

$\varepsilon_0 \Phi = \sigma \frac{4}{3}\pi R^3$

$\Phi = \frac{4\sigma\pi R^3}{3\varepsilon_0}$

Maka medan listriknya adalah:

$\Phi = E.A$

$\frac{4\sigma\pi R^3}{3\varepsilon_0} = E\, 4\pi R^2$

$\frac{\sigma R}{3\varepsilon_0} = E$

$E = \frac{\sigma R}{3\varepsilon_0}$

(4.) Bila kuat medan listrik $E = kr^3 \hat{r}_0$ dalam koordinat bola dengan k = konstan.

a. hitung rapat muatannya

b. Cari muatan total yg terdapat dalam bola dengan jari-jari R berpusat di 0

Jawab:

(a.) $\Phi = E.A$ dengan $E = kr^3 \hat{r}_0$, k = konstan

$\Phi = kr^3 \hat{r}_0 \, 4\pi r^2$

$\Phi = 4\pi k r^5 \hat{r}_0$

$Q = \rho V$ dengan $V = \frac{4}{3}\pi r^3$

$\Phi = \frac{Q}{\varepsilon_0}$.

$4\pi k r^5 \hat{r}_0 = \frac{\rho . V}{\varepsilon_0}$.

$4\pi k r^5 \varepsilon_0 \hat{r}_0 = \rho . \frac{4}{3}\pi r^3$

$3 k r^2 \varepsilon_0 \hat{r}_0 = \rho$

$\rho = 3\varepsilon_0 k r^2 \hat{r}_0$

(b.) $Q_{total} = \rho . V$

$Q_{total} = (3\varepsilon_0 k r^2 \hat{r}_0)(\frac{4}{3}\pi r^3)$

$Q_{total} = 4\varepsilon_0 k \pi r^5 \hat{r}_0$