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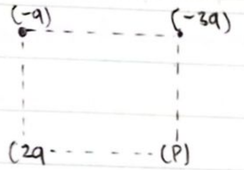
1. a.



Gaya-gaya : - Dari -3q arah ke atas

-q arah ke kiri atas (diagonal)

2q arah ke kanan (karena tolak - menolak)

b. - gaya muatan -3q (Jarak a)

$F_1 = k_e \cdot \frac{|(3q)q|}{a^2} = \frac{3k_e q^2}{a^2}$, arah ke atas

- gaya muatan 2q (Jarak a)

$F_2 = k_e \cdot \frac{|2q \cdot q|}{a^2} = \frac{2k_e q^2}{a^2}$, arah ke kanan

- gaya muatan -q (Jarak)

$F_3 = k_e \cdot \frac{|-q \cdot q|}{(2a^2)} = \frac{k_e q^2}{2a^2}$

- diagonal kiri atas → ubah ke komponen

$F_{3x} = \frac{k_e q^2}{2a^2} \cdot \cos(45°) = -\frac{k_e q^2}{2a^2} \cdot \frac{\sqrt{2}}{2} = -\frac{k_e q^2 \sqrt{2}}{4a^2}$

$F_{3y} = \frac{k_e q^2 \sqrt{2}}{4a^2}$

- gabungkan semua gaya : Komponen - x : $F_x = F_2 + F_{3x} = \frac{2k_e q^2}{a^2} - \frac{k_e q^2 \sqrt{2}}{4a^2}$

Komponen y : $F_y = F_1 + F_{3y} = \frac{3k_e q^2}{a^2} + \frac{k_e q^2 \sqrt{2}}{4a^2}$

total gaya $|\vec{F}| = \sqrt{F_x^2 + F_y^2}$

c. $E_x = \frac{F_x}{q}$, $E_y = \frac{F_y}{q}$

d. $|\vec{E}| = \frac{|\vec{F}|}{q} = \sqrt{E_x^2 + E_y^2}$

e. $V = k_e \cdot \left(\frac{-q}{\sqrt{2}a} + \frac{-3q}{a} + \frac{2q}{a} \right)$

$V = k_e q \left(-\frac{1}{\sqrt{2}a} - \frac{3}{a} + \frac{2}{a} \right) = k_e q \left(-\frac{1}{\sqrt{2}a} - \frac{1}{a} \right)$

2. a. $E = \frac{\lambda}{4\pi\varepsilon_0} \int_0^L \frac{1}{(z-z')^2} dz'$

batas integral

$z' = 0 \Rightarrow u = z$

$z' = L \Rightarrow u = z - L$

Substitusi $u = z - z' \Rightarrow dz' = -du$

$E = \frac{\lambda}{4\pi\varepsilon_0} \int_{z-L}^{z} \frac{1}{u^2} du = \frac{\lambda}{4\pi\varepsilon_0} \left[-\frac{1}{u} \right]_{z-L}^{z} = \frac{\lambda}{4\pi\varepsilon_0} \left(\frac{1}{z-L} - \frac{1}{z} \right)$

b. $E = \frac{\lambda}{4\pi\varepsilon_0} \int_{-L/2}^{L/2} \frac{1}{(z-z')^2} dz'$

Substitusi $u = z - z' \to dz' = -du$

batas • $z' = -L/2 \to u = z + L/2$

• $z' = +L/2 \to u = z - L/2$

$E = \frac{\lambda}{4\pi\varepsilon_0} \int_{z-L/2}^{z+L/2} \frac{1}{u^2} du = \frac{\lambda}{4\pi\varepsilon_0} \left[-\frac{1}{u} \right]_{z-L/2}^{z+L/2} = \frac{\lambda}{4\pi\varepsilon_0} \left(\frac{1}{z-L/2} - \frac{1}{z+L/2} \right)$

3. di dalam bola konduktor $(r < R)$, medan listrik = 0

di luar bola konduktor $(r > R)$, medan listrik dihitung menggunakan hukum gauss

luas permukaan bola : $A = 4\pi R^2$

total muatan Q pada bola : $Q = \sigma A = \sigma \cdot 4\pi R^2$

- medan listrik di luar bola $(r > R)$ → hukum gauss

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{dalam}}{\varepsilon_0}$

$E \cdot 4\pi r^2 = \frac{\sigma \cdot 4\pi R^2}{\varepsilon_0}$

$E = \frac{\sigma R^2}{\varepsilon_0 r^2}$

- medan listrik di dalam bola ($r \leq R$)
Q dalam : $0 \rightarrow E = 0$

karena ini bola konduktor, seluruh muatan berada di permukaan maka tidak ada muatan di dalamnya

Jadi $E(r) = \begin{cases} 0 & \text{untuk } r < R \\ \frac{\sigma R^2}{\varepsilon_0 r^2} & \text{untuk } r > R \end{cases}$

(4) diket : medan listrik : $\vec{E} = kr^3 \hat{r}$

Jawab : a. menggunakan hukum gaus

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0}$$

Dalam koordinat bola, untuk medan radial $\vec{E} = E(r)\hat{r}$:

$$\nabla \cdot \vec{E} = \frac{1}{r^2} \cdot \frac{d}{dr}(r^2 E(r))$$

Substitusi $E(r) = kr^3$.

$$\nabla \cdot E = \frac{1}{r^2} \cdot \frac{d}{dr}(r^2 \cdot kr^3) = \frac{1}{r^2} \cdot \frac{d}{dr}(kr^5) = \frac{1}{r^2} \cdot 5kr^4 = 5kr^2$$

rapat muatan : $\rho(r) = \varepsilon_0 \nabla \cdot \vec{E} = 5k\varepsilon_0 r^2$

b. $Q = \int_v \rho(r)\, dv$

menggunakan volume elemen bola :

$$dv = 4\pi r^2 dr$$

$$Q = \int_0^R \rho(r) \cdot 4\pi r^2 dr = \int_0^R (5k\varepsilon_0 r^2) \cdot 4\pi r^2 dr = 20\pi k \varepsilon_0 \int_0^R r^4 dr$$

$$Q = 2\pi k \varepsilon_0 \cdot \left(\frac{r^5}{5}\right)\Big|_0^R = 20\pi k \varepsilon_0 \cdot \frac{R^5}{5}$$

$$Q = 4\pi k \varepsilon_0 R^5$$