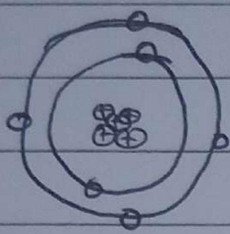
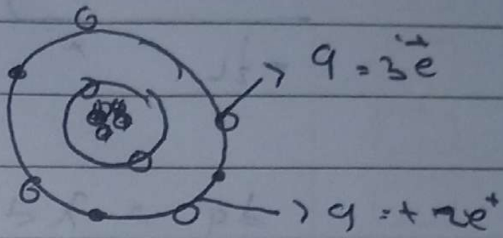
12 September 2025

$\vec{E}$ oleh muatan diskrit



$q = \pm n\bar{e}$

$= z\vec{e}$



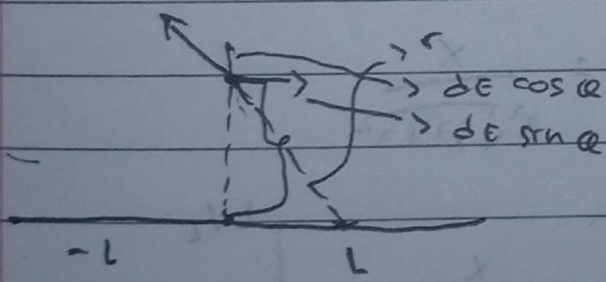
Muatan → Sifat sebuah atom

$\vec{E}$ terdistribusi dalam benda

terdistribusi dalam 1 dimensi

$\hookrightarrow \vec{E} = \dfrac{q}{4\pi\varepsilon_0 r^2}\hat{r}_0$ → diskrit

1. $\vec{E} = \dfrac{1}{4\pi\varepsilon_0}\displaystyle\int \frac{q}{r^2}\,d\ell$ → bentuk garis



$d\vec{E} = dE_y + dE_x = 0$

$= dE_y$

$d\vec{E} = dE\cos\theta$

$\vec{E} = \dfrac{1}{4\pi\varepsilon_0}\displaystyle\int_{-L}^{L}\frac{dq}{r^2}$

$= \dfrac{1}{\square}\displaystyle\int_{-L}^{L}\lambda\frac{dl}{r^2}\cos\theta$

$= \dfrac{1}{\square}\displaystyle\int_{0}^{2L}\lambda\frac{dl}{r^2}\cos - \frac{1}{\square}\int_{0}^{2L}\frac{\lambda dl}{r^2}\cos\theta$

$= \dfrac{1}{\square}\displaystyle\int_{0}^{2L}\frac{\lambda z}{r^2}\,dl$

$\vec{E} = \dfrac{1}{\square}\displaystyle\int_{0}^{2}\frac{\lambda z\,dl}{(z^2+l^2)^{3/2}}$

$E = \dfrac{z\lambda}{4\pi\varepsilon_0}\left[\dfrac{2L}{z(z^2+(L)^2)}\right]$

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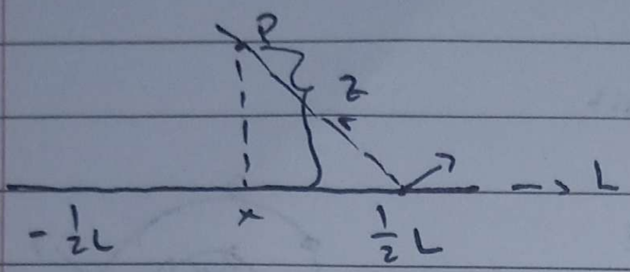


$$dq = \lambda\, dx$$

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

$$dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}\hat{r}$$

$$dE_z = dE\cos\theta = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}\frac{z}{r} = \frac{1}{4\pi\varepsilon_0}\frac{\lambda z\, dx}{(x^2+z^2)^{3/2}}$$

$$E_z = \frac{\lambda z}{4\pi\varepsilon_0}\int_{-L/2}^{L/2}\frac{dx}{(x^2+z^2)^{3/2}}$$

$$= \int\frac{dx}{(x^2+z^2)^{3/2}} = \frac{x}{z^2\sqrt{x^2+z^2}}$$

$$= E_z = \frac{\lambda z}{4\pi\varepsilon_0}\left[\frac{x}{z^2\sqrt{x^2+z^2}}\right]_{-L/2}^{L/2}$$

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

19 September 2025

Medan non diskrit

Hukum Gauss dalam bentuk integral

$$\oiint \vec{E}\, d\vec{s} = \iiint \nabla \vec{E}\, ds \qquad \vec{E} = \frac{q}{4\pi \varepsilon_0 r^2}$$

$$\oint \vec{E}\, d\vec{s} = \int \nabla \vec{E}\, ds$$

$$\oint \vec{E}\, ds = \frac{1}{4\pi \varepsilon_0} \int_0^{2\pi} \int_0^{\pi} \frac{Q}{r^2} r^2 \sin\theta\, d\theta\, d\phi$$

$$= \frac{1}{4\pi \varepsilon_0} 2\pi \int_0^{\pi} Q \sin\theta\, d\theta$$

$$= \frac{Q(2\pi)}{4\pi \varepsilon_0} \left[-\cos\theta \Big|_0^{\pi} \right]$$

$$= \frac{\cancel{4\pi}\, Q}{\cancel{4\pi} \varepsilon_0} = \frac{Q}{\varepsilon_0}$$

$$\oint \vec{E}\, ds = \frac{Q}{\varepsilon_0}$$

$$\iiint \nabla \vec{E} \, d\varsigma$$

$$\nabla \vec{E} = \frac{1}{4\pi\varepsilon_0} \iiint \nabla\left(\frac{\hat{r}}{r^2}\right) \rho \, d\sigma$$

$Q = \rho \, dg$

$$= \frac{1}{4\pi\varepsilon_0} \rho \int \nabla\left(\frac{\hat{r}}{r^2}\right) dg$$

$$= \frac{\rho}{4\pi\varepsilon_0} \left[4\pi \, dg\right]$$

$$= \frac{4\pi\rho}{4\pi\varepsilon_0}$$

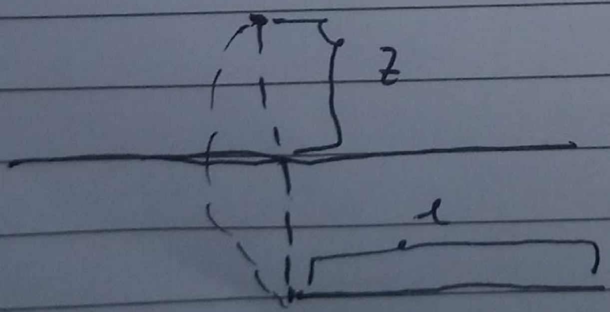
Contoh

1. Hitung medan listrik pada kawat lurus panjang sejauh z

$Q = \lambda l$

$Q = \sigma A$

$Q = \rho V$



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$E \oint ds = E (S)$

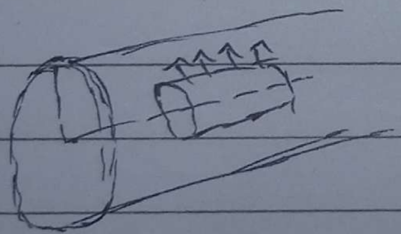
$\oint \vec{E} \, d\vec{s} = \frac{Q}{\varepsilon_0}$

$E \cdot S = \frac{\lambda l}{\varepsilon_0}$

$E \cdot 2\pi z \cancel{l} = \frac{\lambda \cancel{l}}{\varepsilon_0}$

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

Sebuah silinder pejal panjang sekali, dengan jari² silinder R, rapat muatan q, hitung medan listrik di dalam silinder!



(Rapat bergantung pada rapat dan dimana letaknya)

$\oint_S E\, ds = \frac{Q}{\varepsilon_0} \to \rho\, d\tau$

$= \frac{1}{\varepsilon_0} \iiint \rho\, dq$

$= \frac{\rho}{\varepsilon_0} \int_0^l \int_0^r \int_0^{2\pi} r\, d\theta\, dr\, dz$

$= \frac{2\pi l}{\varepsilon_0} \int_0^\tau \int_0^r r\, dr\, dz$

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$$= \frac{2\pi \rho L}{\varepsilon_0} \int_0^r r\,dr$$

$$= \frac{2\pi \rho L}{\varepsilon_0} \left[\frac{1}{2} r^2 \Big|_0^r \right]$$

E - S

$$E(2\pi r \ell) = \frac{2\pi \rho L}{2\varepsilon_0} \left[r^2 - 0 \right]$$

$$E(2\pi r L) = \frac{\pi \rho L r^2}{\varepsilon_0}$$

$$E = \frac{\rho r^2}{2r \varepsilon_0} = \frac{\rho r}{2\varepsilon_0}$$