"Medan Elektromagnetik"

29 Agustus 2025 Jum'at

1. Sistem koordinat.
2. Medan listrik dan magnet.

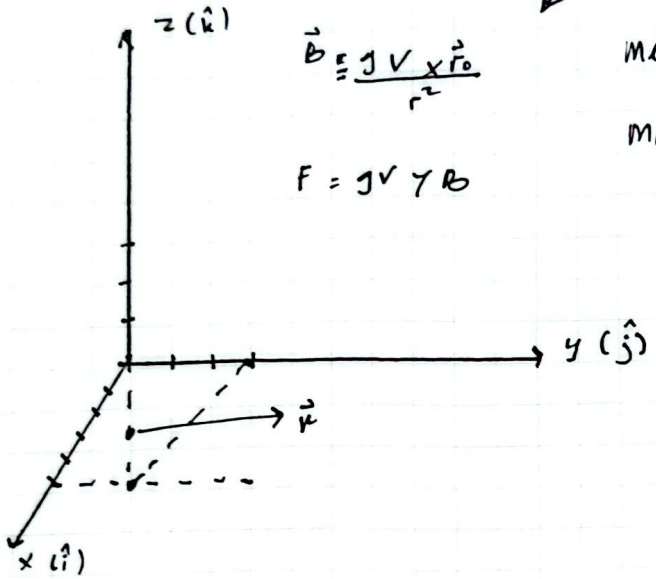
$\vec{v} = x\hat{i} + y\hat{j} + z\hat{k}$ (konstan)

$\vec{v} = 5\hat{i} + 3\hat{j} + 1\hat{k}$

$\vec{B} = i\,d\vec{r} \times \rightarrow F = BiL$ dst

Medan magnet → arus listrik

Medan listrik → oleh muatan




$\vec{B} = \frac{J V \times \vec{r}_0}{r^2}$

$F = JV \times B$

Medan listrik ($\vec{E}$)

Elektromagnetik → gelombang yang dihasilkan oleh muatan listrik.

Muatan → sifat dari sebuah benda (atom)

Medan magnet

$$\vec{g} = G\frac{M}{r^2}\hat{r}_0$$

$$E = k\frac{q}{r^2}\hat{r}_0$$

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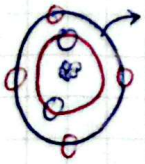
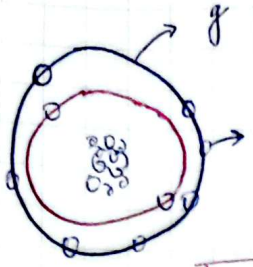
$\vec{E}$ oleh muatan diskrit



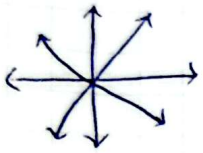


$q$ $\quad q = \pm n_1 e$
$= 2e$

Jika diberi muatan

$\boxed{q = 3e}$

$\boxed{q = +2e^+}$ Jika dilepas



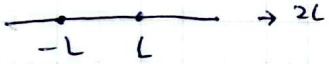
$\vec{E} = \frac{1}{4\pi} \frac{2qe}{r^2}$

- Medan distribusi
- $\vec{E}$ → terdistribusi oleh bahan

$\vec{E} = \frac{q}{4\pi\varepsilon_0 r^2}$ $\quad r^2 \rightarrow$ diskrit

① $\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{q}{r^2} dl \rightarrow$ bri bentuk garis

Contoh :




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

$= dE_y$

$dE = dE \cos\theta$

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

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

$= \frac{1}{\square} \int_0^{2L}$

$= \frac{1}{\square} \int_0^{2L} \frac{\lambda z}{r^3} dl$

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$r = (z^2 + l^2)^{1/2}$

$\vec{E} = \frac{1}{\square} \int_0^{2L} \frac{\lambda z\, dl}{(z^2+l^2)^{3/2}}$

$= \frac{z\lambda}{\square} \int \frac{dl}{(z^2+l^2)^{3/2}}$

$= \frac{z\lambda}{\square} \left[ \frac{l}{z^2 (z^2+l^2)^{1/2}} \right]_0^{2L}$

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

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

$= dE_y$

$dE = dE \cos\theta$

$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int_{-1/2L}^{1/2L} \frac{dq}{r^2} \cos\theta$

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

Tugas

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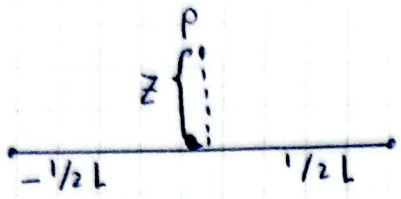
Problem :




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

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

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

↓

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

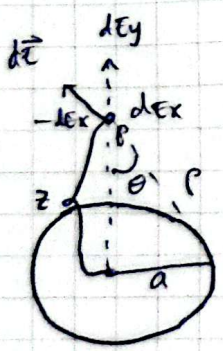
$$\int_{-L/2}^{L/2}\frac{dx}{(x^2+z^2)^{3/2}} = \left[\frac{x}{z^2\sqrt{x^2+z^2}}\right]_{-L/2}^{L/2}$$

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

$$E_z(P) = \frac{\lambda L}{4\pi\varepsilon_0\, z\sqrt{z^2+\left(\frac{L}{2}\right)^2}}$$

Note :
Menjauhkan thk. gauss

← Saling meniadakan




$$d\vec{E} = dE_x + dE_y$$
$$= dE_y$$
$$= dE\cos\theta$$

$$\vec{E} = dE\cos\theta = \frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a}\frac{\lambda\,dl\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a}\frac{\lambda z}{r^3}\,d\ell$$

$$= \frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a}\frac{xz}{(z^2+a^2)^{3/2}}\,dl$$

$$= \frac{\lambda z}{4\pi\varepsilon_0(z^2/a^2)^{3/2}}\,l\Big|_0^{2\pi a}$$

$$\vec{E} = \frac{\lambda z}{4\pi\varepsilon_0(z^2+a^2)^{3/2}}$$

$$= \frac{\chi\, q\, a}{\ldots}$$

→

→ elemen muatan kecil ($dq$)
hitung garis yang sangat kecil dengan panjang $dx$ pada posisi $x$. Muatan

$$\boxed{dq = \lambda\, dx}$$

→ Medan listrik dari $dq$
- jarak $r$ dari $dq$ ke P

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

- Besar medan listrik $dE$

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

→ Analisis komponen vektor
- Komponen vertikal

$$\boxed{dE_z = dE\cos\theta}$$

- Dari geometri gambar

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

- substitusi menjadi satu

$$dE_z = \left(k\frac{\lambda dx}{x^2+z^2}\right)\left(\frac{z}{\sqrt{x^2+z^2}}\right)$$

$$= \frac{k\lambda z\, dx}{(x^2+z^2)^{3/2}}$$

→ Integrasi untuk mendapatkan medan total

$$E_P = E_z = \int_{-l/2}^{l/2} \frac{k\lambda z}{(x^2+z^2)^{3/2}}\, dx$$

- keluarkan konstanta dari integral

$$E_P = k\lambda z \int_{-l/2}^{l/2} \frac{1}{(x^2+z^2)^{3/2}}\, dx$$

$$\int \frac{1}{(x^2+z^2)^{3/2}}\, dx = \frac{x}{z^2\sqrt{x^2+z^2}}$$

- Evaluasi integral

$$E_P = k\lambda z\left[\frac{x}{z^2\sqrt{x^2+z^2}}\right]_{-l/2}^{l/2}$$

$$= \frac{k\lambda}{z}\left[\frac{l}{\sqrt{l^2/4+z^2}}\right]$$

→ Hasil akhir

$$E = \frac{k\lambda l}{z\sqrt{l^2/4+z^2}}$$

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

$$= \frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a} \frac{\lambda\, dL\cos\theta}{r^2}$$

$$\downarrow$$

$$\frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a} \frac{\lambda z}{r^3}\, d\ell$$

$$\frac{1}{4\pi\varepsilon_0}\int_0^{2\pi a} \frac{xz}{(z^2+a^2)^{3/2}}\, d\ell$$

$$= \frac{xz}{4\pi\varepsilon_0(z^2+a^2)^{3/2}}\,\ell\Big|_0^{2\pi a}$$

$$\vec{E} = \frac{\lambda z\, 2\pi a}{4\pi\varepsilon_0(z^2+a^2)^{3/2}}$$

$$= \frac{\lambda z\, a}{2\varepsilon_0(z^2+a^2)^{3/2}}$$