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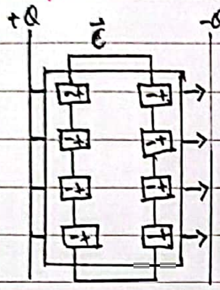
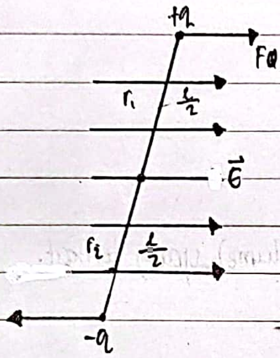
1. Gambarkan bahan dielektrik

Penyelesaian :





Momen gaya oleh dipol

$$N = (r_+ \times F_+) + (r_- \times F_-)$$
$$= \left(\frac{l}{2} \times (qE)\right) + \left(-\frac{l}{2} \times (-qE)\right)$$
$$= \left(\frac{l}{2} \times (qE)\right) - \left((-qE) \times \left(-\frac{l}{2}\right)\right)$$
$$= \left(\frac{l}{2} \times (qE)\right) + \left((qE) \times \left(\frac{l}{2}\right)\right)$$
$$= q\frac{l}{2} E \sin\theta + qE\frac{l}{2}\sin\theta$$
$$= q\vec{l}\vec{E}\sin\theta$$
$$\vec{N} = q\vec{l} \times \vec{E}$$
$$\therefore N = \vec{P} \times \vec{E}$$

2. Nilai N untuk F yang tidak saling mengimbangi

Penyelesaian:

Bila medan $\vec{E}$ tidak seragam gaya F_+ dan F_- tidak tepat saling mengimbangi, maka

$$F = F_+ + F_-$$
$$= q(\vec{E}_+ - \vec{E})$$
$$= q\, dE$$

$u, l \ll 1$, sehingga gradiennya:

$$\nabla.\vec{E}.\vec{l} = dE \rightarrow d\vec{E} = (\nabla.\vec{l}).\vec{E}$$
$$F = q[(\nabla.\vec{l}).\vec{E}] = q[\vec{l}.(\nabla.\vec{E}) + \nabla.(\vec{l}.\vec{E})]$$
$$\nabla.\vec{E} = \frac{1}{\varepsilon_0}\rho, \text{ karena } \rho = 0$$
$$\nabla.\vec{E} = 0$$
$$\vec{F} = q(\nabla.(\vec{l}.\vec{E}))$$
$$\vec{F} = \nabla.(\vec{P}.\vec{E})$$

Penurunan rumus apabila N untuk F yang saling tidak mengimbangi:

Jika gaya F_+ dan F_- tidak saling mengimbangi:

$$F = F_+ + F_-$$
$$= q(\vec{E}_+ - \vec{E})$$
$$= q\, dE$$

$$N = (r_+ \times F_+) + (r_- \times F_-)$$
$$= \left(\frac{l}{2} \times \nabla(\vec{P}\vec{E})\right) + \left(\frac{l}{2} \times (-\nabla(\vec{P}\vec{E}))\right)$$
$$= \left(\frac{l}{2} \times \nabla(\vec{P}\vec{E})\right) + \left(-\nabla(\vec{P}\vec{E}) \times -\frac{l}{2}\right)$$
$$= \left(\frac{l}{2} \times \nabla(\vec{P}\vec{E})\right) + \left(\nabla(\vec{P}\vec{E}) \times \frac{l}{2}\right)$$
$$\vec{N} = \vec{l}.\nabla\vec{P}\vec{E}$$

3. Medan didalam bahan dielektrik terpolarisasi

Penyelesaian:

Dengan teorema Gauss

$$V = \frac{1}{4\pi\varepsilon_0} \oint \frac{1}{r} \vec{P} \cdot d\vec{A} - \frac{1}{4\pi\varepsilon_0} \int \frac{1}{r} (\nabla \cdot \vec{P})\, d\tau$$

Suku pertama, potensial disebabkan oleh muatan permukaan yang terikat

$$V = \frac{1}{4\pi\varepsilon_0} \oint \frac{\vec{P}}{r}\, d\vec{A}$$

$$= \frac{1}{4\pi\varepsilon_0} \oint \frac{1}{r} \vec{P} \cdot \hat{n}\, dA$$

$$\vec{P} \cdot \hat{n} = \sigma_b$$

Suku kedua, potensial karena rapat muatan (volume) yang terikat.

$$V = \frac{1}{4\pi\varepsilon_0} \int \frac{1}{r} (-\vec{\nabla} \cdot \vec{P})\, d\tau$$

$$-\nabla \cdot \vec{P} = \rho_b$$

$$\rho_b = -\nabla \cdot \vec{P}$$

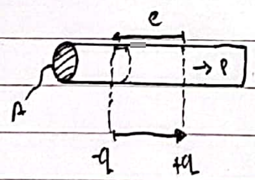
∴ Potensial didalam bahan dielektrik yang terpolarisasi:

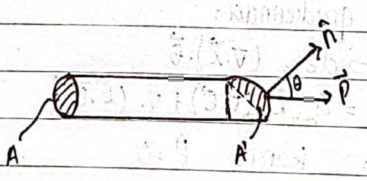
$$V = \frac{1}{4\pi\varepsilon_0} \oint \frac{\sigma_b}{r}\, dA + \frac{1}{4\pi\varepsilon_0} \int \frac{\rho_b}{r}\, d\tau$$

4. Tabung dielektrik yang mempunyai polarisasi $\vec{P}$ seragam didalamnya

Momen dipol didalam elemen volume kecil sepanjang l:

$$\vec{P} = \vec{P}(A \cdot l)$$





$$\vec{P} \cdot \hat{n} = P \cos\theta$$

$$P = \frac{\sigma_b}{A'} \cdot \frac{\sigma_0 \cos\theta}{A}$$

$$\sigma_b = \frac{q}{A}$$

$\vec{P} \cdot \hat{n} = \sigma_b \cdot P \cdot \hat{n}$ = berimpit

$$P = \sigma_b$$

$$P = \frac{q}{A}$$

$$PA = q$$