Nama : Rizka Agustin

Kelas : B

No.

Date : 25 - 4 - 2024

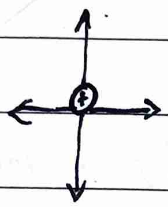
## Medan Listrik

↳ area / daerah dimana sebuah muatan didekatkan masih ada / terpengaruh gaya coulumb

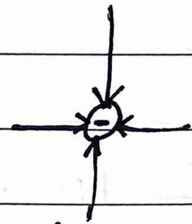
diketahui :

Q = muatan utama

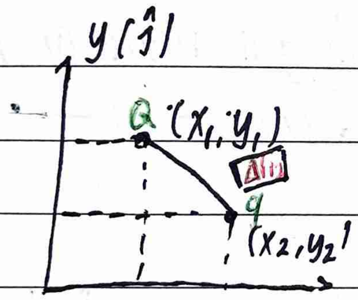
q = muatan uji



(medan positif)



(medan negatif)




$$\boxed{F_{Qq} = q \cdot E_0}$$

$$\boxed{F_{Qq} = 0 \quad F_{Qq} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \cdot q}{r^2_{Qq}} \cdot \hat{r}_{Qq}} \longrightarrow \boxed{\hat{r}_{Qq} = \frac{\Delta x \hat{i} + \Delta y \hat{j}}{\sqrt{\Delta x\hat{i}^2 + \Delta y \hat{j}^2}} = \frac{\vec{r}_{Qq}}{|\vec{r}_{Qq}|}}$$

$$\boxed{|\vec{r}_{Qq}| = r_{Qq} = \sqrt{\Delta x^2 + \Delta y^2}}$$

$$E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \cdot q}{r^2_{Qq}} \cdot \hat{r}_{Qq}$$

$$\boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_{Qq}} \cdot \hat{r}_{Qq}} \quad \boxed{E_Q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r_{Qq}^3} \cdot \vec{r}_{Qq}}$$

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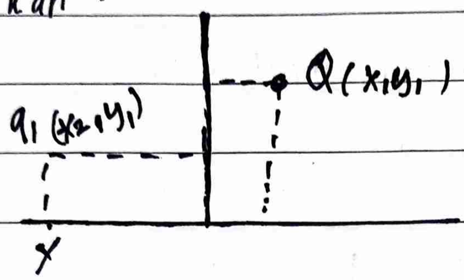
Misalkan :



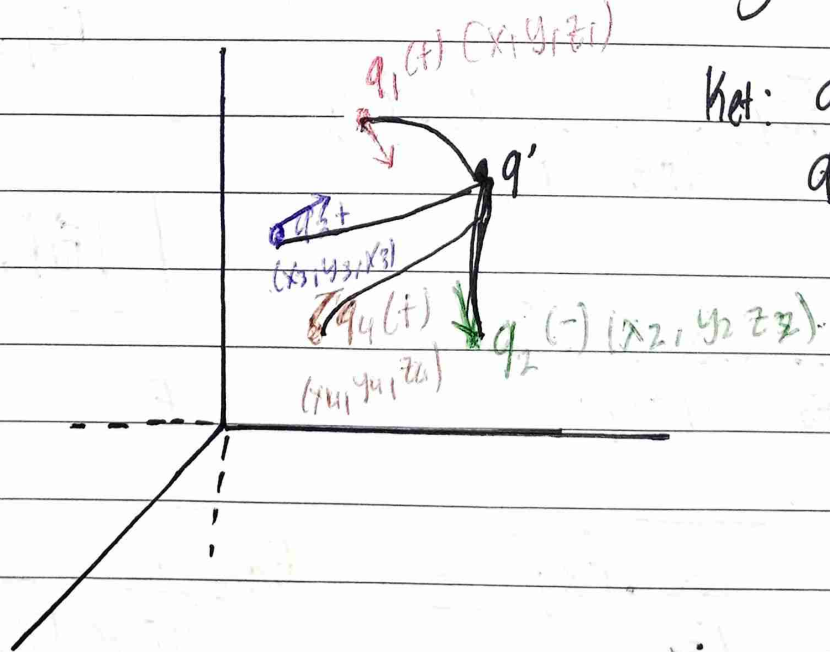

$$\boxed{\vec{E}_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{q_{12}^2} \hat{r}_{12}}$$

$q_1$ = sebagai muatan utama
$q_2$ = sebagai muatan uji

$$\boxed{E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_2}{q_{21}^2} \hat{r}_{21}}$$

$q_1$ = sebagai muatan ~~utama~~ uji
$q_2$ = sebagai —॥— utama

# Medan Listrik Pada Banyak Muatan




Ket: $q'$ = muatan uji
$q_1, q_2, q_3, q_4$ = muatan utama

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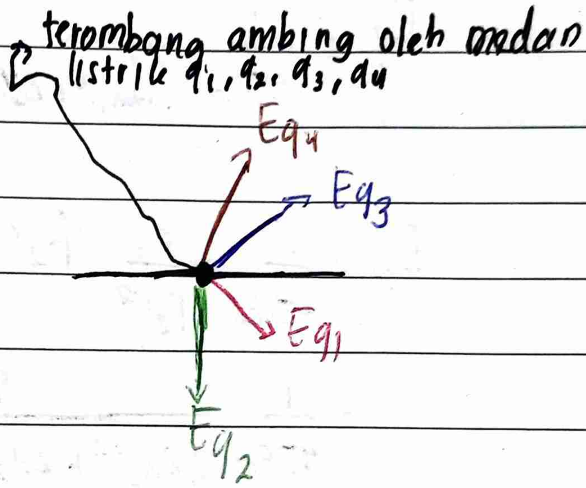
$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_1^2} \hat{r}_1$$

$$E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_2}{r_2^2} \hat{r}_2$$

$$E_{q_3} = \frac{1}{4\pi\varepsilon_0} \frac{q_3}{r_3^2} \hat{r}_3$$

$$E_{q_4} = \frac{1}{4\pi\varepsilon_0} \frac{q_4}{r_4^2} \hat{r}_3$$




$q_1 < q_2 < q_3 < q_4$

$$\hat{r}_{1'} = \frac{\vec{r}_{1'}}{|\vec{r}_{1'}|} = \frac{\Delta x_{1'}\hat{i} + \Delta y_{1'}\hat{j} + \Delta z_{1'}\hat{k}}{\sqrt{\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2}}$$

$$\vec{r}_1 = \Delta x_1 \hat{i} + \Delta y_1 \hat{j} + + \Delta z_1 \hat{k}$$

$x' - x_1$ $\quad$ $y' - y_1$ $\quad$ $z' - z$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_{1'}^2} \hat{r}_{1'}$$

$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}} \cdot \frac{\Delta x_{1'}\hat{i} + \Delta y_{1'}\hat{j} + \Delta z_{1'}\hat{k}}{(\Delta x_{1'}^2 + \Delta y_{1'}^2 + \Delta z_{1'}^2)^{\frac{1}{2}}}$$

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$$E_{q_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}} \cdot (\Delta x_1'\hat{i} + \Delta y_1'\hat{j} + \Delta z_1'\hat{k})$$

$$E_{q_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_2}{r_2'^2} \hat{r}_2'$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_2}{((\Delta x_2'^2 + \Delta y_2'^2 + \Delta z'^2)^{\frac{1}{2}})^2} \cdot \frac{\Delta x_2'\hat{i} + \Delta y_2'\hat{j} + \Delta z_2'\hat{k}}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}} (\Delta x_2'\hat{i} + \Delta y_2'\hat{j} + \Delta z_2'\hat{k})$$

$$E_{q_3} = \frac{1}{4\pi\varepsilon_0} \frac{q_3}{r_3'^2} \hat{r}_3$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_3}{((\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}})^2} \cdot \frac{\Delta x_3'\hat{i} + \Delta y_3'\hat{j} + \Delta z_3'\hat{k}}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_3}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}} \cdot \Delta x_3'\hat{i} + \Delta y_3'\hat{j} + \Delta z_3'\hat{k}$$

$$E_{q_4} = \frac{1}{4\pi\varepsilon_0} \frac{q_4}{r_4'^2} \hat{r}_4$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_4}{((\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{3}}} \cdot \Delta x_4'\hat{i} + \Delta y_4'\hat{j} + \Delta z_4'\hat{k}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_4}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}} \cdot \Delta x_4'\hat{i} + \Delta y_4'\hat{j} + \Delta z_4'\hat{k}$$

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$$E_{total} = E_{q'} = E_{q_1} + E_{q_2} + E_{q_3} + E_{q_4}$$

$$E_{q'} = \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}} + \left(\frac{1}{4\pi\varepsilon_0}\frac{1}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)}\right.\right.$$

$$\frac{q_2}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}}(\Delta x_2'\hat{i} + \Delta y_2'\hat{j} + \Delta z_2'\hat{k})\Big) + \left(\frac{1}{4\pi\varepsilon_0}\frac{1}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)}\right.$$

$$\frac{q_3}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{1/2}}(\Delta x_3'\hat{i} + \Delta y_3'\hat{j} + \Delta z_3'\hat{k})\Big)\Big) + \left(\frac{1}{4\pi\varepsilon_0}\frac{1}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)}\right.$$

$$\frac{q_4}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}}(\Delta x_4'\hat{i} + \Delta y_4'\hat{j} + \Delta z_4'\hat{k})$$

$$E_{q'} = \frac{1}{4\pi\varepsilon_0}\left(\left(\frac{q_1}{(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)(\Delta x_1'^2 + \Delta y_1'^2 + \Delta z_1'^2)^{\frac{1}{2}}}(\Delta x_1'\hat{i} + \Delta y_1'\hat{j} + \Delta z_1\hat{k})\right) + \right.$$

$$\left(\left(\frac{q_2}{(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)(\Delta x_2'^2 + \Delta y_2'^2 + \Delta z_2'^2)^{\frac{1}{2}}}(\Delta x_2'\hat{i} + \Delta y_2'\hat{j} + \Delta z_2'\hat{k})\right)\right) +$$

$$\left(\left(\frac{q_3}{(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)(\Delta x_3'^2 + \Delta y_3'^2 + \Delta z_3'^2)^{\frac{1}{2}}}(\Delta x_3'\hat{i} + \Delta y_3'\hat{j} + \Delta z_3'\hat{k})\right)\right.$$

$$\left(\left(\frac{q_4}{(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)(\Delta x_4'^2 + \Delta y_4'^2 + \Delta z_4'^2)^{\frac{1}{2}}}(\Delta x_4'\hat{i} + \Delta y_4'\hat{j} + \Delta z_4'\hat{k})\right)\right.$$

# Medan Listrik Yang Dihasilkan Distribusi Muatan

| | Cartesian $(x, y, z)$ | Cylindrical $(\rho, \phi, z)$ | Spherical $(r, \theta, \phi)$ |
|---|---|---|---|
| $dl$ | $dx, dy, dz$ | $d\rho, \rho d\phi, dz$ | $dr, r d\theta, r \sin\theta d\phi$ |
| $dA$ | $dx dy, dy dz, dz dx$ | $d\rho dz, \rho d\phi dz, \rho d\phi d\rho$ | $r dr d\theta, r \sin\theta dr d\phi, r^2 \sin\theta d\theta d\phi$ |
| $dv$ | $dx dy dz$ | $\rho d\rho d\phi dz$ | $r^2 \sin\theta dr d\theta d\phi$ |

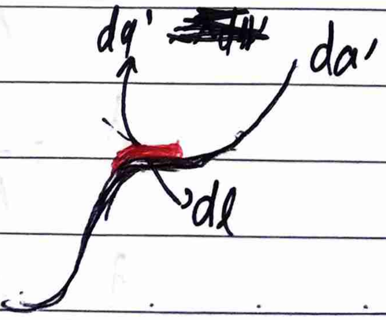
Keterangan $dl$ = Panjang
$dA$ : Luas
$dv$ : volume

Rapat muatan : Suatu (Quantitas) muatan listrik yang terdistribusi dalam suatu bidang tertentu dan ruang tertentu.

exampel :

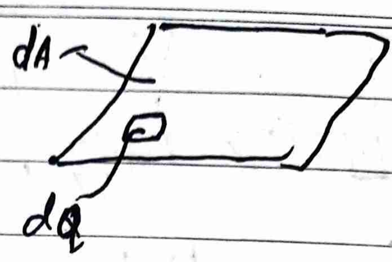
1 Rapat muatan panjang $(ds')$ atau $(dl')$

$$\lambda = \frac{dq'}{dl} \quad \text{atau} \quad \lambda = \frac{dq'}{dl'}$$



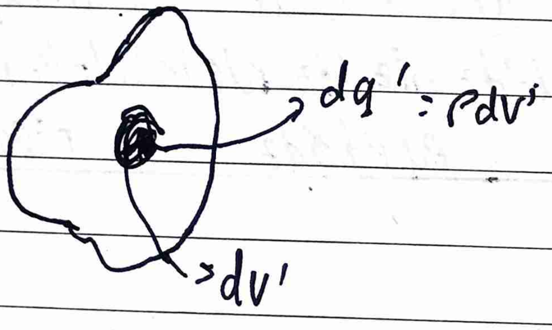
2 Rapat muatan luas (da)

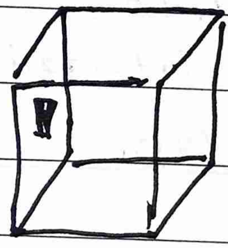
$$\sigma = \frac{dq'}{dA}$$



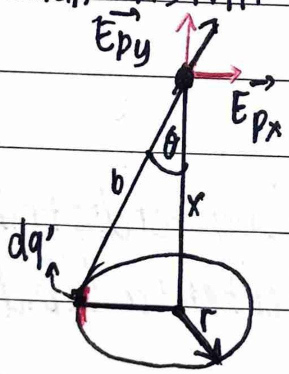

2 Rapat muatan volume

$$\rho = \frac{dq}{dv}$$



# Medan listrik di Sumbu




keliling cincin = $2\pi r$

Kerapatan muatan cincin

$$\lambda = \frac{q}{l}$$

$$\lambda = \frac{q}{K}$$

$$\lambda = \frac{q}{2\pi r} = \frac{q}{L} = \frac{\partial q}{\partial L}, \quad \partial q = \lambda . dL$$

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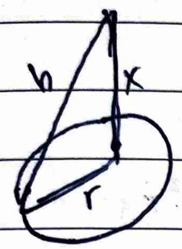
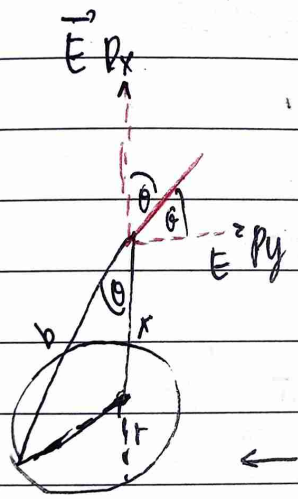



$$\boxed{E_q = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}}$$

$$\boxed{E_{\partial q} = \frac{1}{4\pi\varepsilon_0}\frac{\partial q}{b^2}}$$

$$E_{\partial q} = \frac{1}{4\pi\varepsilon_0}\frac{\lambda \cdot \partial l}{(r^2+x^2)}$$

$$\boxed{E_{\partial q} = \frac{1}{4\pi\varepsilon_0}\int\frac{\lambda \cdot \partial l}{(r^2+x^2)}}$$




$L = 2\pi r$

$\partial L = 2\pi\, \partial \cdot r$

$$\boxed{\sin\theta = \frac{r}{(r^2+x^2)^{\frac{1}{2}}}}$$

← medan listrik disumbu

$$\boxed{\cos\theta = \frac{x}{(r^2+x^2)^{\frac{1}{2}}}}$$

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

$\lambda = \frac{q}{L}$ atau $\lambda = \frac{q}{2\pi r}$

$\lambda = \frac{\partial q}{\partial L} \rightarrow \partial q = \lambda \cdot \partial L$

$$E_Q = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$E_{\partial q} = \frac{1}{4\pi\varepsilon_0}\frac{\lambda\, \partial L}{(r^2+x^2)}$$

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$$\vec{E}_{py} = \vec{E}_p \sin\theta = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda \cdot \partial L}{(r^2+x^2)} \sin\theta$$

$$= \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda \cdot 2L}{(r^2+x^2)} \frac{r}{(r^2+x^2)^{\frac{1}{2}}}$$

$$\vec{E}_{px} = E_p \cos\theta = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dl}{(r^2+x^2)} \cos\theta$$

$$= \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda\, dl}{(r^2+x^2)} \frac{x}{(r^2+x^2)^{\frac{1}{2}}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{3/2}} \int dl'$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{3/2}} \int_0^r 2\pi\, dr$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{3/2}} 2\pi \int_0^r dr \,.$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\lambda x}{(r^2+x^2)^{3/2}} 2\pi \,[r]_0^r$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{(\lambda 2\pi r)x}{(r^2+x^2)^{3/2}}$$

$$\boxed{E_p = \frac{1}{4\pi\varepsilon_0} \frac{q_x}{(r^2+x^2)^{3/2}}}$$

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$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \frac{q_x}{(r^2+x^2)^{3/2}}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \frac{q_x}{((r^2+x^2)^{1/2})^3}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \frac{q_x}{b^3}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} q \frac{1}{b^2} \frac{x}{b}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} q \frac{1}{b^2} \frac{x}{b} \frac{r^2}{r^2}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \frac{r^2}{b^2} \frac{x}{b}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \sin^2\theta \cos\theta$$

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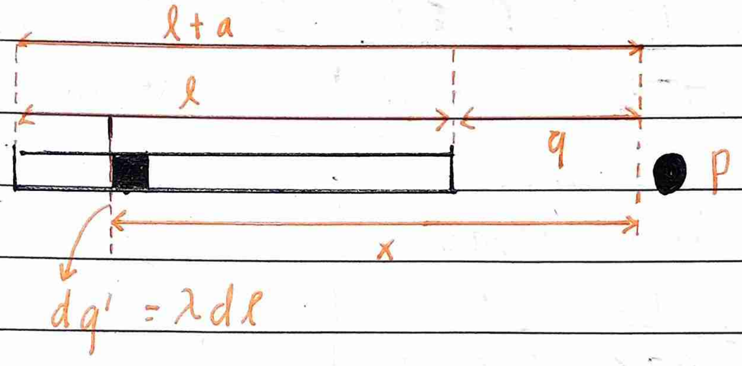
# Medan Listrik Oleh Muatan Batang




Medan yang dihasilkan elemen tersebut pada titik P adalah

$$\vec{E}_p = k \int \frac{dq'}{r^2}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda\, dl'}{x^2}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \int_a^{l+a} \frac{dx}{x^2}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \int_a^{l+a} \left(\frac{1}{x^2}\right) dx$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \left[-\frac{1}{x}\right]_a^{l+a}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \left[\left\{-\frac{1}{l+a}\right\} - \left\{-\frac{1}{a}\right\}\right]$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0} \lambda \left[\left\{\frac{1}{a}\right\} - \left\{\frac{1}{l+a}\right\}\right]$$

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$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0}\lambda\left[\left\{\frac{l+a}{a(l+a)}\right\} - \left\{\frac{a}{a(l+a)}\right\}\right]$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0}\lambda\left\{\frac{(l+a)-a}{a(l+a)}\right\}$$

$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0}\lambda\left\{\frac{l}{a(l+a)}\right\}$$

$$E_p = \frac{1}{4\pi\varepsilon_0}\frac{\lambda l}{(al+a^2)}$$

$$\boxed{E_p = \frac{1}{4\pi\varepsilon_0}\frac{q}{(al+a^2)}}$$