Ex 24.3 (continued)

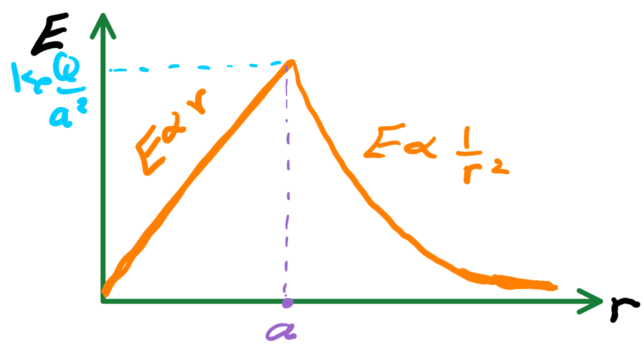
(A) $E = k_e \frac{Q}{r^2}$ for $r > a$ (outside) → (1)

(B) $E = k_e \frac{Q}{a^3} r$ for $r < a$ (inside) → (2)

* $E = ?$ for $r = a$

Use eqn (1) or (2) ⇒ $E = k_e \frac{Q}{a^2}$

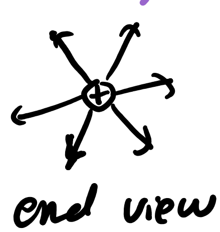
* for $r = 0$ ⇒ use eqn (2) → $E = 0$

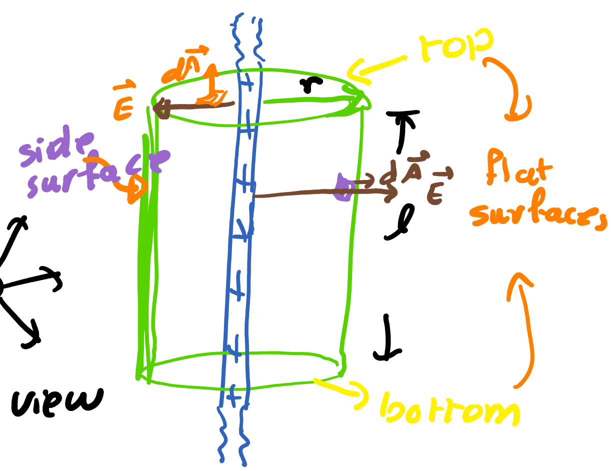


Ex 24.4:

$E = ?$ at a distance r from infinite line of charge of constant λ.

we choose a cylindrical G-surface





$$\underbrace{\oint \vec{E} \cdot d\vec{A}}_{= ?} = \frac{q_{in}}{\varepsilon_0} = ?$$

$$\oint \vec{E} \cdot d\vec{A} = \cancel{\int_{top} \vec{E} \cdot d\vec{A}} + \cancel{\int_{bottom} \vec{E} \cdot d\vec{A}} + \int_{side} \vec{E} \cdot d\vec{A}$$

ϕ ~~top~~ ~~bottom~~ side

Note that:

(1) for the flat surfaces (top and bottom)

$\hookrightarrow \vec{E} \perp d\vec{A} \Rightarrow \vec{E}\cdot d\vec{A} = 0$

(2) for the side surface $\Rightarrow \vec{E} \parallel d\vec{A} \Rightarrow \vec{E}\cdot d\vec{A} = E\,dA$

$$\Rightarrow \oint \vec{E}\cdot d\vec{A} = \int_{side} E\,dA = E \int_{side} dA = 2\pi r \ell$$

area of the side surface

$$\Rightarrow \oint \vec{E}\cdot d\vec{A} = 2\pi r \ell \times E$$

$q_{in} = ? \Rightarrow q_{in} = \lambda \ell$

$$\Rightarrow \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0} \Rightarrow E(2\pi r \cancel{\ell}) = \frac{\lambda \cancel{\ell}}{\varepsilon_0}$$

$$\Rightarrow \boxed{E = \frac{\lambda}{2\pi\varepsilon_0 r} = 2 k_e \frac{\lambda}{r}}$$

$\hookrightarrow E \propto \frac{1}{r}$