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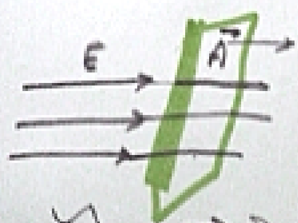
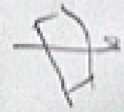
Gauss' Law

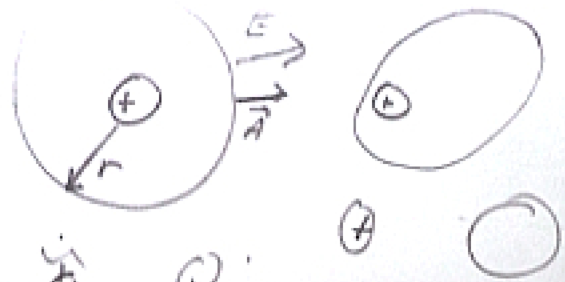
$$\Phi_E = \frac{Q_{enc}}{\varepsilon_0}$$





$$\Phi_E = \vec{E}\cdot\vec{A} = EA$$

$$\boxed{\Phi = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta\vec{A}_i}$$



$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

On GS:

$\vec{E} \parallel \vec{A}$

$|\vec{E}|$ constant

$$\Phi_E = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta\vec{A}_i$$

$$= \sum_{\Delta A_i} E_i \Delta A_i = E \sum_{\Delta A_i} \Delta A_i$$

$$= \underline{E(4\pi r^2)}$$

$$\Phi_E = \frac{Q_{enc}}{\varepsilon_0}$$

On GS:

$\vec{E} \parallel \vec{A}$

$|\vec{E}|$ constant

$$\Phi_E = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta \vec{A}_i$$

$$= \sum_{\Delta A_i} E_i \Delta A_i = E \sum_{\Delta A_i} \Delta A_i$$

$$= E(4\pi r^2)$$

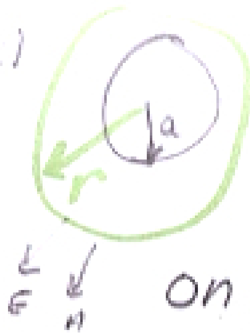
$$Q_{enc} = Q$$

$$E(4\pi r^2) = \frac{Q}{\varepsilon_0}$$

$$\vec{E} = \frac{Q}{4\pi \varepsilon_0 r^2}\hat{r} \quad \Big|\Big| \quad \vec{E} = \frac{kq}{r^2}\hat{r}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

(a)



$$\rho = \frac{Q}{\frac{4}{3}\pi a^3}$$

on GS: $\vec{E} \parallel \vec{A}$

$|\vec{E}|$ uniform

$$\Phi_E = \frac{q_{enc}}{\varepsilon_0} \qquad \boxed{q_{enc} = Q}$$

$$\Phi_E = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta\vec{A}_i = \sum_{\Delta A_i} E_i \Delta A_i$$

$$= E \sum_{\Delta A_i} \Delta A_i = E(4\pi r^2)$$

on GS: $\vec{E} \parallel \vec{A}$

$|\vec{E}|$ uniform

$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

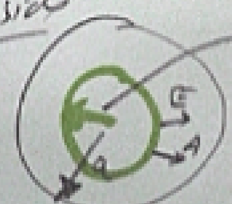
$$\boxed{q_{enc} = Q}$$

$$\Phi = \oint \vec{E} \cdot d\vec{A} = \sum E \Delta A$$

$$E(4\pi r^2) = \frac{Q}{\varepsilon_0}$$

$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\hat{r}$$

Inside



$r \le a$

on GS:

$\vec{E} \parallel \vec{A}$

$|\vec{E}|$ uniform

$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

$$\Phi_E = E(4\pi r^2)$$

ε_0

$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\hat{r}$$

Inside

$r \le a$

on GS:

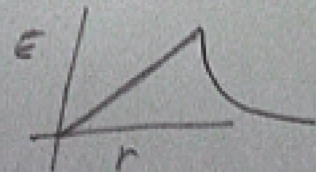
$\vec{E} \parallel \vec{A}$

$$Q_{enc} = \rho \cdot \text{Volume}$$

$$= \rho\left(\frac{4}{3}\pi r^3\right)$$

$$E(4\pi r^2) = \frac{\rho}{\varepsilon_0}\left(\frac{4}{3}\pi r^3\right)$$

$$\vec{E} = \frac{\rho}{\varepsilon_0}\vec{r} \quad \text{m} \quad \rho = \frac{Q}{\frac{4}{3}\pi a^3}$$



$r \le a$

on GS:

$\vec{E} \parallel \vec{A}$

$|\vec{E}|$ uniform

$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

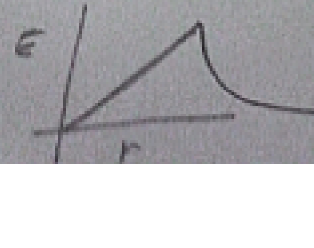
$$\Phi_E = E(4\pi r^2)$$

$$q_{enc} = \rho \cdot \text{Volume}$$

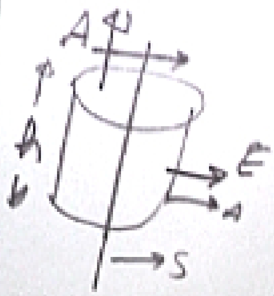
$$= \rho\left(\frac{4}{3}\pi r^3\right)$$

$$E(4\pi r^2) = \frac{\rho}{\varepsilon_0}\left(\frac{4}{3}\pi r^3\right)$$

$$\vec{E} = \frac{\rho}{\varepsilon_0}\vec{r} \quad \rho = \frac{q}{\frac{4}{3}\pi a^3}$$



$\lambda = \dfrac{Q}{\text{Length}}$



OBAGS:

ENDS: $\vec{E} \perp \vec{A}$

LSA: $\vec{E} \parallel \vec{A}$, $|\vec{E}|$ const

$$\Phi_E = \frac{Q_{enc}}{\varepsilon_0}$$

$$\Phi_E = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta \vec{A}_i$$

$$= \sum_{\substack{\Delta A_i \\ \text{ENDS}}} \vec{E}_i \cdot \Delta \vec{A}_i + \sum_{\substack{\Delta A_i \\ \text{LSA}}} \vec{E} \cdot \Delta \vec{A}_i$$

$$= 0 + E \sum_{\text{LSA}} \Delta A_i$$

$$\Phi_E = E(2\pi s h)$$

END: $\vec{E} \perp \vec{A}$

LSA: $\vec{E} \parallel \vec{A}$, $|\vec{E}|$ const

$$\Phi_E = \frac{Q_{enc}}{\varepsilon_0}$$

$$\Phi_E = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta\vec{A}_i$$

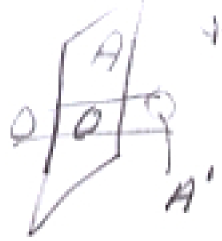
$$= \sum_{\substack{\Delta A_i \\ \text{ENDS}}} \vec{E}_i \cdot \Delta\vec{A}_i + \sum_{\substack{\Delta A_i \\ \text{LSA}}} \vec{E} \cdot \Delta\vec{A}_i$$

$$= 0 + E \sum_{\text{LSA}} \Delta A_i$$

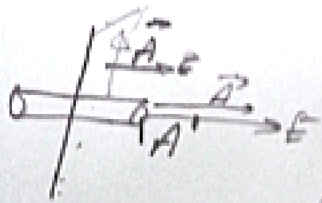
$$\Phi_E = E(2\pi s h) \quad // \quad Q_{enc} = \lambda h$$

$$E(2\pi s h) = \frac{\lambda h}{\varepsilon_0}$$

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 s}\hat{s}$$



$$\sigma = \frac{Q}{\text{Area}}$$



on GS:
LSA: $\vec{E} \perp \vec{A}$

on ENDS
$\vec{E} \parallel \vec{A}$

$$\oint_E = \frac{Q_{enc}}{\varepsilon_0}$$

$\sigma = \frac{\Psi}{\text{Area}}$

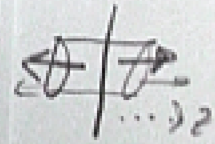
on GS:

LSA: $\vec{E} \perp \vec{A}$

on ENDS

$$\Phi_E = \Phi_{ENDS} + \Phi_{LSA}$$

ϕ



$$\phi_{LSA} = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta \vec{A}_i$$

$$= 0$$

$$\phi_{ENDS} = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta \vec{A}_i$$

$$= \sum_{\Delta A_i} E_i \Delta A_i$$

$$= E \sum_{\Delta A_i} \Delta A_i$$

$$= 2EA$$

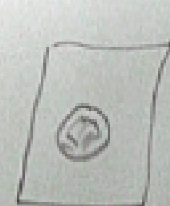
$$\Phi_{E,ND} = \sum_{\Delta A_i} \vec{E}_i \cdot \Delta \vec{A}_i$$

$$= \sum_{\Delta A_i} E_i \Delta A_i$$

$$= E \sum_{\Delta A_i} \Delta A_i$$

$$= 2EA'$$

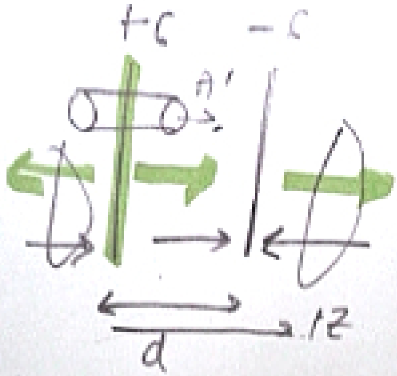
$$\phi = \frac{Q_{enc}}{\varepsilon_0}$$



$$Q_{enc} = \sigma A'$$

$$2EA' = \frac{\sigma A'}{\varepsilon_0}$$

$$\vec{E} = \frac{\sigma}{2\varepsilon_0} \; z \begin{cases} +z : \hat{z} \\ -z : -\hat{z} \end{cases}$$



$$\Phi_E = EA' \qquad Q_{enc} = \sigma A'$$

$$EA' = \frac{\sigma A'}{\varepsilon_0}$$

$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{z} \quad (0 \text{ outside})$$