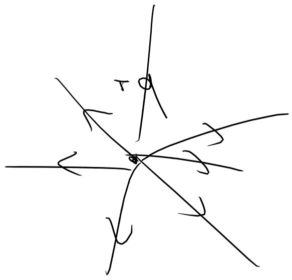
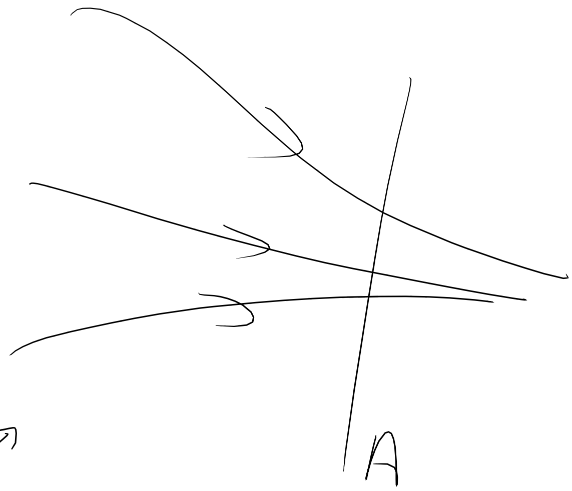
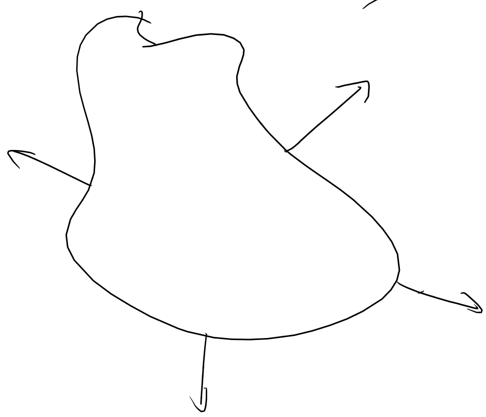


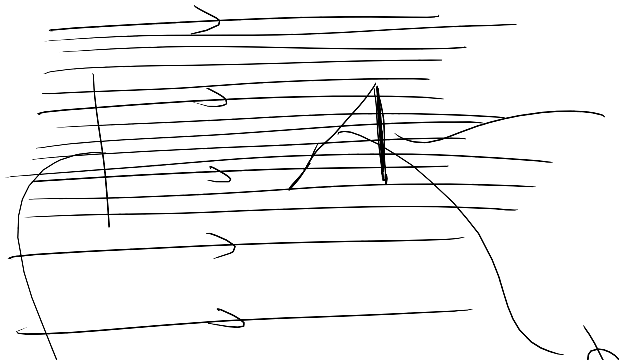


$\propto \vec{E} \cdot \vec{A}$



A

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



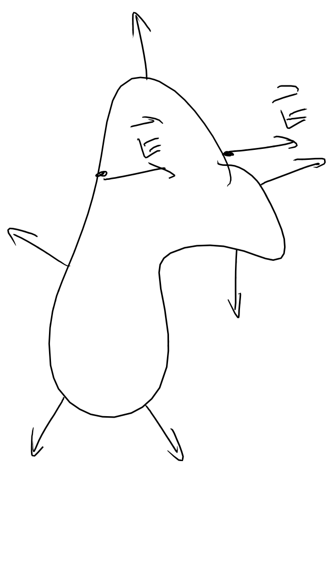
$A \cos\Theta$

$\Phi_E = \int \vec{E} \cdot d\vec{A}$

arbitrary surface

$\Phi = EA \cos\Theta$

$\Phi = EA$



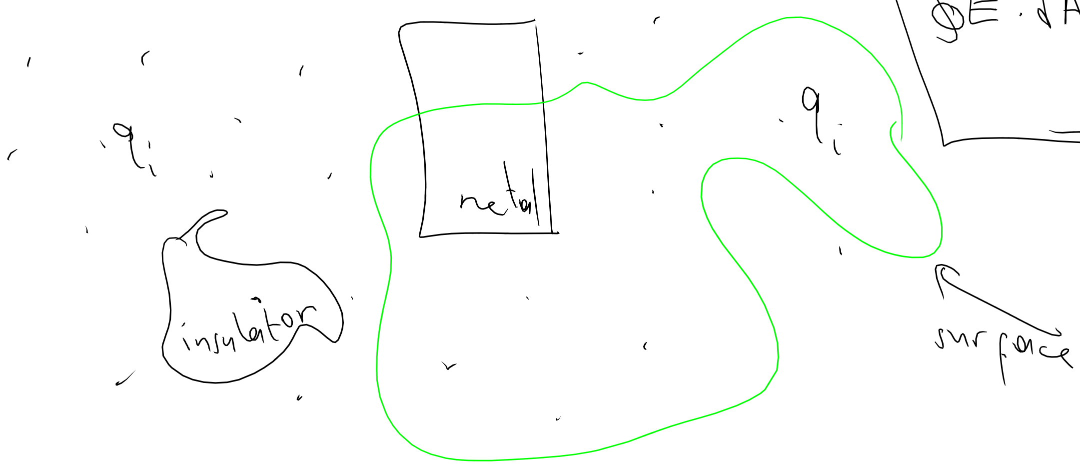
$\Phi_E = \oint \vec{E} \cdot d\vec{A} = 0$

+q

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

Gauss' Law

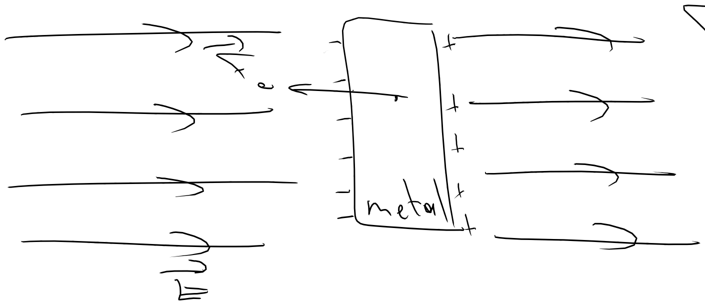
$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$



$\oint$ ← over a closed surface

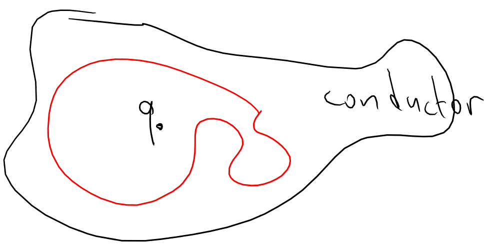
Electric Field in a Conductor = 0
in electrostatics

$$\vec{F} = q\vec{E}(\vec{r})$$



Example

$q = ?$

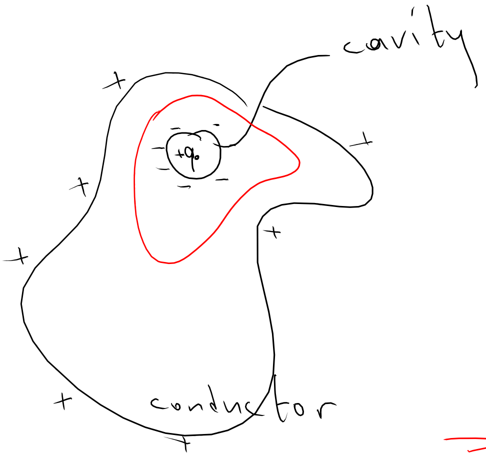


$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

$$\vec{E} = 0$$

$$\Rightarrow Q_{enc} = q = 0$$

Ex

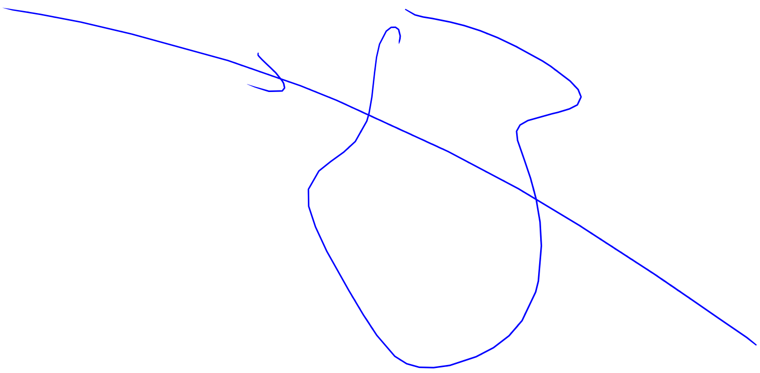


- what is the total charge in the inner surface?

$$\oint \vec{E}\cdot d\vec{A} = 0 = \frac{Q_{enc}}{\varepsilon_0}$$

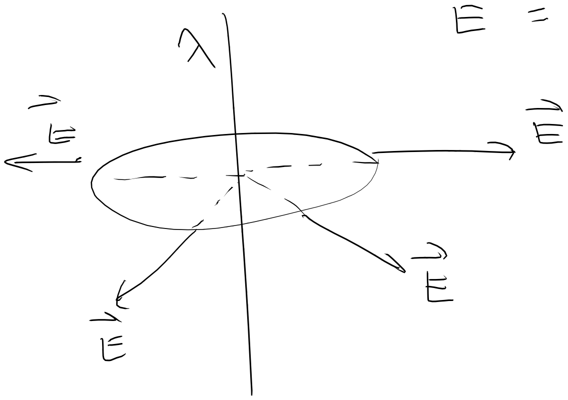
$$Q_{enc} = (+q) + Q_{inner\ surface}$$

$$\boxed{Q_{inner\ surface} = -q}$$



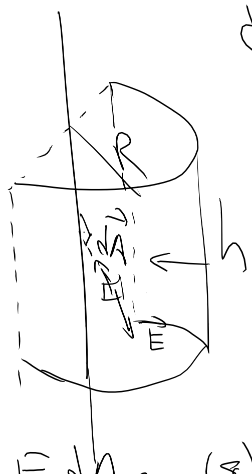
Example

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



$$\phi_E = \int \vec{E}\cdot d\vec{A}$$

$\phi_E = ?$



$$\vec{E}\cdot d\vec{A} = E\,dA\cos(\pi)$$

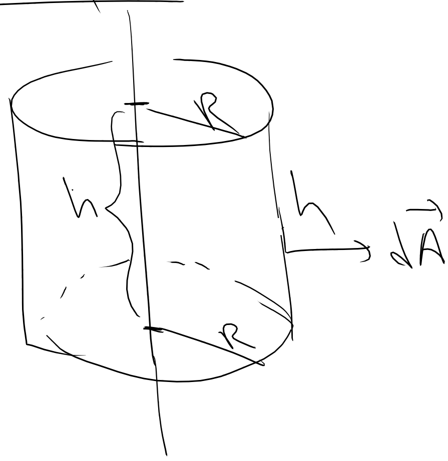
$$\vec{E}\cdot d\vec{A} = -\frac{\lambda}{2\pi\varepsilon_0 R}\,dA$$

$$\phi_E = \int \vec{E}\cdot d\vec{A} = \sum\left(-\frac{\lambda}{2\pi\varepsilon_0 R}\,dA\right)$$

$$= -\frac{\lambda}{2\pi\varepsilon_0 R}\sum dA = -\frac{\lambda}{2\pi\varepsilon_0 R}\,2\pi R h$$

$$\phi_E = -\left(\frac{\lambda h}{\varepsilon_0}\right)\left(\frac{1}{2}\right)$$

Example



$$\phi_E = \left(\frac{\lambda h}{\varepsilon_0}\right) = \frac{(\lambda h)}{\varepsilon_0}$$

$$\int \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

Example

$$\oint \vec{E} \cdot d\vec{A} = \overset{0}{\overset{\parallel}{\int_{top} \vec{E} \cdot d\vec{A}}} + \overset{0}{\overset{\parallel}{\int_{bottom} \vec{E} \cdot d\vec{A}}}$$

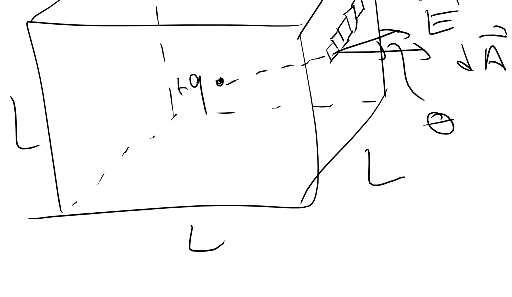
$$+ \underset{\frac{\lambda h}{\varepsilon_0}}{\underset{\parallel}{\int_{side} \vec{E} \cdot d\vec{A}}}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

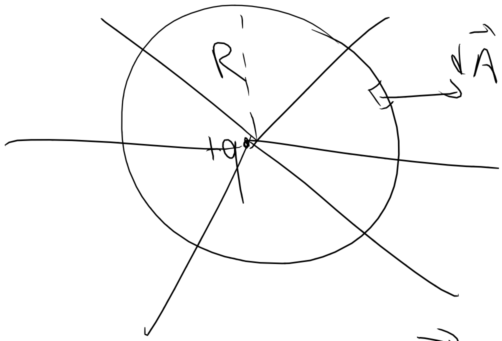
Example

$$\phi_{side} = ?$$

$$\frac{q}{\varepsilon_0} = \oint \vec{E} \cdot d\vec{A} = \sum \phi_{side} = 6\phi_{side}$$



__Example__ Electric field of a point charge using Gauss' Law.



$$d\vec{A} = dA\hat{r}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

$$\vec{E} = E(r)\hat{r}$$

choose a spherical Gauss' surface.

$$d\vec{A} = dA\hat{r}$$

$$\vec{E} \cdot d\vec{A} = E(R)\, dA \cos(0) = E(R)\, dA$$

$$\oint \vec{E} \cdot d\vec{A} = \oint E(R)\, dA = E(R)\, 4\pi R^2 = \frac{q}{\varepsilon_0}$$

$$\boxed{E(R) = \frac{1}{4\pi\varepsilon_0} \frac{q}{R^2}}$$