2-6-2019: Flux and Gauss's Law

Wednesday, February 6, 2019 9:02 AM

From last time, we calculated the next flux going through a cube. We'll relate the flux to the enclosed charge.

$$\Phi_{net} = 36-12+16-16+0+0 = 24\,\frac{N}{C}m^2 \Longrightarrow q_{enc} = \varepsilon_0 \Phi_{net} = \varepsilon_0 \times 24 = \underline{2.1\times 10^{-10}\,C}$$

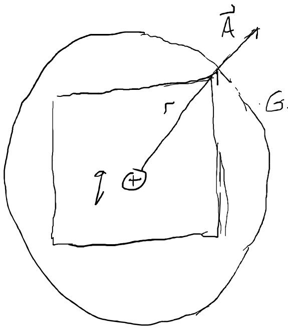
q_{enc} ← ENCLOSED CHARGE

GAUSS'S LAW $\varepsilon_0 \Phi = q_{enc}$. $\Phi = \oint \vec{E}\cdot d\vec{A} \Rightarrow \boxed{\varepsilon_0 \oint \vec{E}\cdot d\vec{A} = q_{enc}}$

-OR- $\Phi = \frac{q_{enc}}{\varepsilon_0}$

$q_{enc} > 0 \Leftrightarrow \Phi > 0$ outward

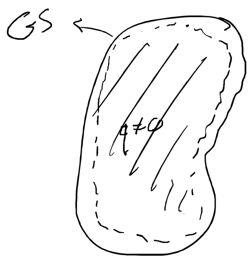
$q_{enc} < 0 \Leftrightarrow \Phi < 0$ inward



$$\varepsilon_0 \oint \vec{E}\cdot d\vec{A} = q$$

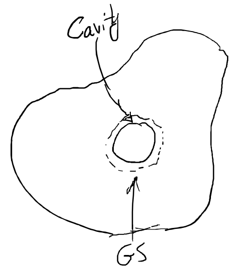
$$\varepsilon_0 \oint \vec{E}\cdot d\vec{A} = \varepsilon_0 E \oint dA$$

$$q = \varepsilon_0 E\, 4\pi r^2 \Rightarrow \boxed{E = \frac{q}{4\pi\varepsilon_0 r^2}}$$

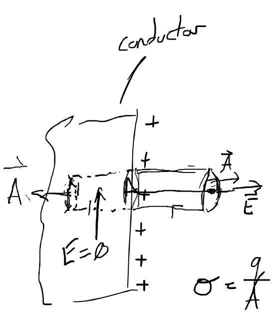


Lump of copper, excess charge in electrostatic equilibrium.

$$I_{current} = 0 \Rightarrow \vec{E}_{inside} = 0$$



No electric field in the cavity, because there are no enclosed charges there!



$\sigma = \frac{q}{A}\left(\frac{C}{m^2}\right)$

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

$$\varepsilon_0 \int E_{out}\, dA + \underbrace{\varepsilon_0 \int \cancel{E_{middle}}\, dA}_{0\ (\text{CURVED})} + \overbrace{\varepsilon_0 \int \cancel{E_{in}}\, dA}^{0\ (\text{conductor})} \Rightarrow \varepsilon_0 E_{out} \oint dA = q_{enc}$$

$$\varepsilon_0 E_{out} A = q_{enc}$$

$$\varepsilon_0 E_{out} A = q_{enc}$$

area of the cap

$$q_{enc} = \sigma A \Rightarrow \varepsilon_0 E_{out} = \sigma \Rightarrow \boxed{E = \frac{\sigma}{\varepsilon_0}}$$

surface of conductor