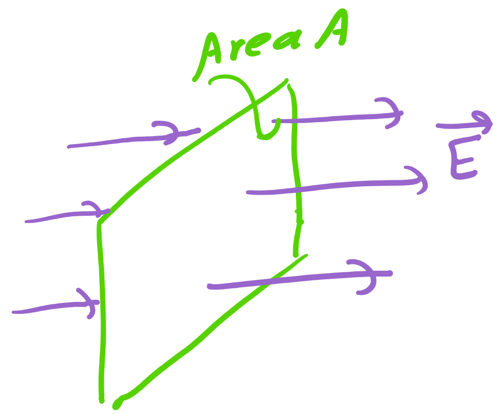
Lecture 10 (12-1)

Tuesday, March 16, 2021 12:02 PM

Ch.24 / Gauss's Law

24.1 Electric Flux

$A \perp \vec{E}$



Remember: number of lines is $\propto |\vec{E}|$

$\Rightarrow$ Total number of lines penetrating the surface is

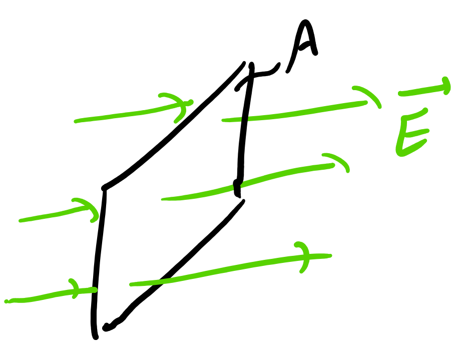
$\propto EA = \Phi_E$ → electric flux

SI units of $\Phi_E \Rightarrow \frac{N}{C} \cdot m^2 = N \cdot m^2/C$

• If A is NOT $\perp$ $\vec{E}$

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

θ = angle between normal to area and $\vec{E}$



$\theta = 0$

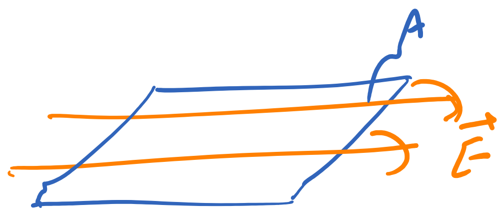
$\Rightarrow \Phi_E = EA\cos 0°$

$\Rightarrow \Phi_E = EA$

$\theta = 90°$

$\Rightarrow \Phi_E = EA\cos 90°$

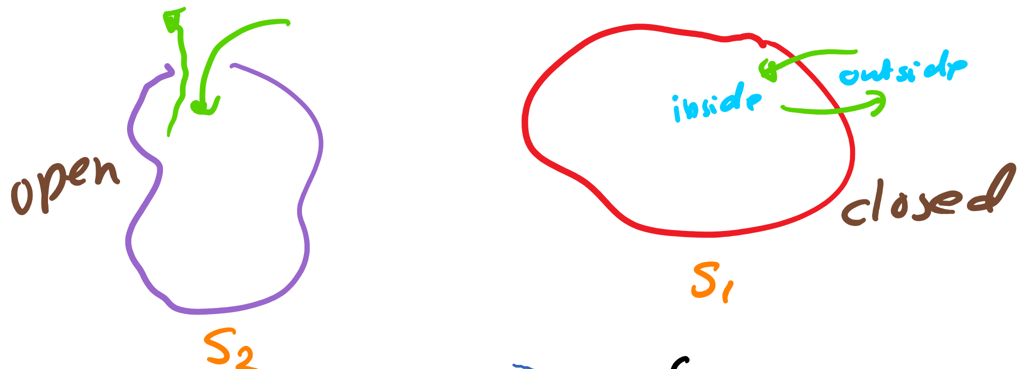
$$\Rightarrow \Phi_E = EA\cos 90 = \text{zero}$$



General definition of Φ_E

$$\boxed{\Phi_E \equiv \int_{\text{surface}} \vec{E}\cdot d\vec{A}}$$

- Φ_E through a closed surface



$$\Rightarrow \Phi_E = \oint \vec{E}\cdot d\vec{A} = \oint E_n\, dA$$

$\hookrightarrow$ The component of the electric field normal to the surface

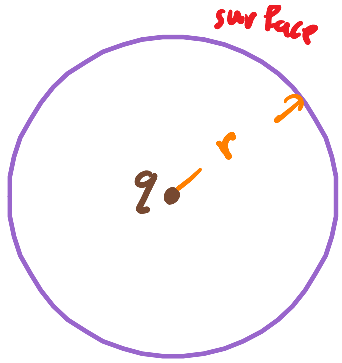
$$\vec{E}\cdot d\vec{A} = E_n\, dA \cos 0^\circ = E_n\, dA$$

QQ 24.1:

at the surface $\leftarrow E, \Phi_E \rightarrow$ through the surface

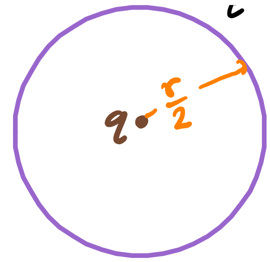
$E = ?$

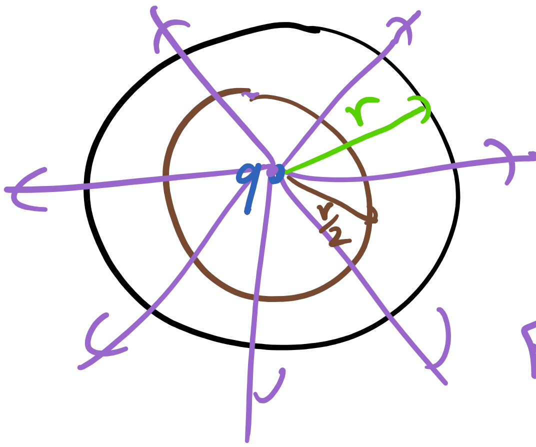
$\Phi_E = ?$



Now

$r \to \frac{r}{2}$





$\boxed{\begin{array}{l}\text{Answer is (e)} \\ \phi_E \text{ same} \\ E \text{ increases}\end{array}}$

why?

$\phi_E \propto$ number of lines penetrating the surface

$\Rightarrow \phi_E \equiv$ same for both surfaces

$$EA = \phi_E \Rightarrow E = \frac{\phi_E}{A}$$

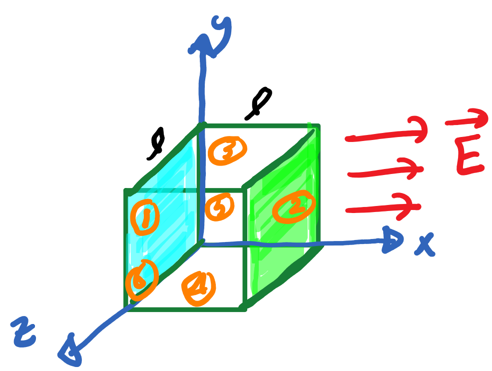
since decreases $\Rightarrow$ E increases

OR $E = k_e \frac{q}{r^2}$ since $r \to \frac{r}{2}$

$\Rightarrow$ E increases

Ex 24.1:

$\phi_{net} = ?$



$$\phi_{net} = \phi_1 + \phi_2 + \cancel{\phi_3} + \cancel{\phi_4} + \cancel{\phi_5} + \cancel{\phi_6}$$

$$\boxed{\phi_3 = \phi_4 = \phi_5 = \phi_6 = \text{zero}}$$

$\boxed{\Phi_3 = \Phi_4 = \Phi_5 = \Phi_6 = \text{zero}}$

$\Rightarrow \Phi_{net} = \Phi_1 + \Phi_2$

$\Phi_1 = \int \vec{E} \cdot d\vec{A} = \int E \, dA \cos 180^\circ$

$= -E \int dA = \ell^2$

$\Rightarrow \Phi_1 = -E\ell^2$

$\Phi_2 = \int \vec{E} \cdot d\vec{A} = \int E \, dA \cos 0^\circ$

$= E \int dA = \ell^2$

$\Rightarrow \Phi_2 = E\ell^2$

$$\boxed{\Phi_{net} = \Phi_1 + \Phi_2 = -E\ell^2 + E\ell^2 = \text{zero}}$$