Lecture 14 (12-1)

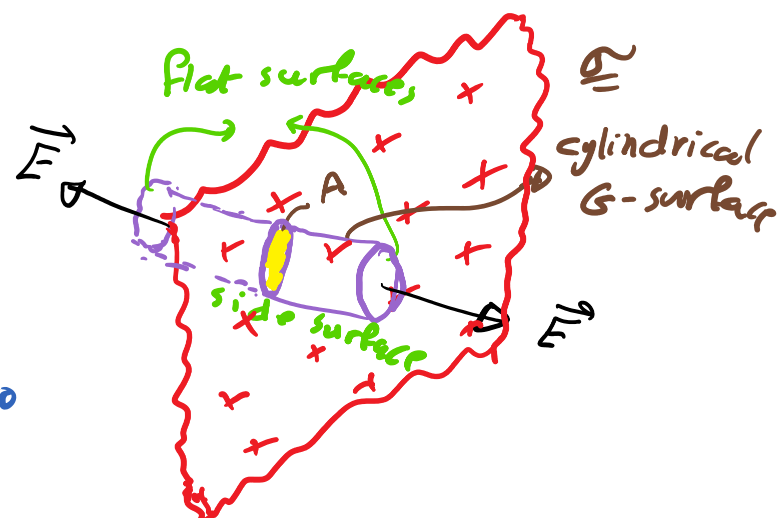
Thursday, March 25, 2021 12:00 PM

Note that in Ex 24.4 if the line segment is not infintely long ⇒ The result we obtained will NOT apply.

---

Ex 24.5:

Infinite plane of charge of uniform $\sigma$




• $\Phi_E$ through the side surface = zero.

↳ $\vec{E} \perp d\vec{A} \Rightarrow \vec{E}\cdot d\vec{A} = \text{zero}$

• $\Phi_E$ through the flat surfaces $\neq$ zero

↳ $\vec{E} \parallel d\vec{A} \Rightarrow \vec{E}\cdot d\vec{A} = E\,dA$

$$\Phi_{net} = \Phi_{\text{2-flat surfaces}} + \cancel{\Phi_{\text{side surface}}}$$

flux through each flat surface

$= \int \vec{E}\cdot d\vec{A} = \int E\,dA$

$= E\int dA = A$

$= EA$

$$\Rightarrow \Phi_{net} = 2EA$$

$q_{in} = ? \Rightarrow q_{in} = \sigma A$

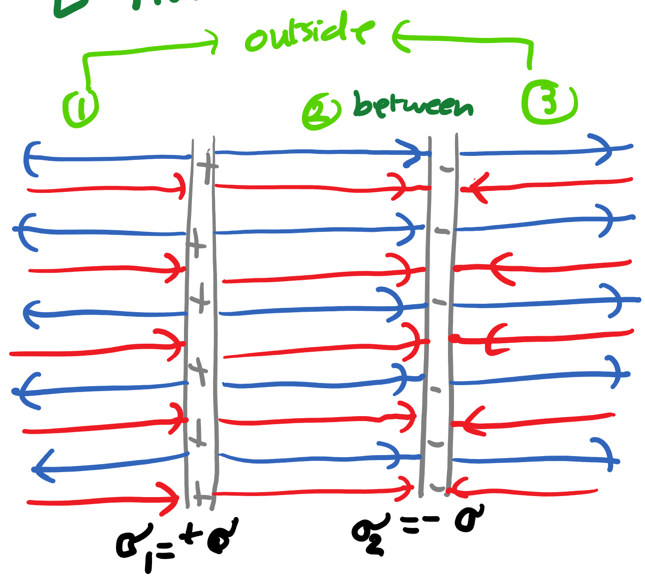
$$\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

$$\Rightarrow 2E\cancel{A} = \frac{\sigma \cancel{A}}{\varepsilon_0}$$

$$\Rightarrow \boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

⇒ The electric field is independent of the distance from the infinite plane → E-field is uniform everywhere.

$E = ?$ in regions: ①, ②, and ③




blue for (+)

red for (−)

- For regions ① and ③ [outside], we subtract:

$$\Rightarrow E_{out} = \left| E_+ - E_- \right| = \left| \frac{|\sigma_1| - |\sigma_2|}{2\varepsilon_0} \right| \longrightarrow (1)$$

$$= \left| \frac{\sigma - \sigma}{2\varepsilon_0} \right| = \text{zero}$$

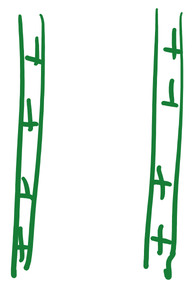
- For region ② [between], we add:

$$\Rightarrow E \;\; = \left| E_+ + E_- \right| = \left| \frac{|\sigma_1| + |\sigma_2|}{2\varepsilon_0} \right| \longrightarrow (2)$$

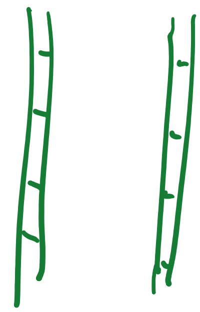
$$\Rightarrow E_{between} = |E_+ + E_-| = \left| \frac{\quad}{2\varepsilon_0} \right| \rightarrow (2)$$

$$= \left| \frac{\sigma + \sigma}{2\varepsilon_0} \right| = \frac{\sigma}{\varepsilon_0}$$

What IF?



OR



$\Rightarrow$ between $\rightarrow$ subtract
outside $\rightarrow$ add

$\Rightarrow$ You use eqn(1) for the region between the planes (subtract), and eqn(2) for the outside region (Add).

## 24.4 Conductors in Electrostatic Equilibrium

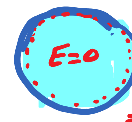
# Properties of a Conductor in Electrostatic Equilibrium

- When there is no net motion of charge within a conductor, the conductor is said to be in **electrostatic equilibrium.**

1. The electric field is zero everywhere inside the conductor.
    - Whether the conductor is solid or hollow

If $\vec{E} \neq 0 \Rightarrow \vec{F} \neq 0 \Rightarrow$ motion ✓
$\rightarrow \vec{E}$ must be zero inside

2. If the conductor is isolated and carries a charge, the charge resides on its surface.




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

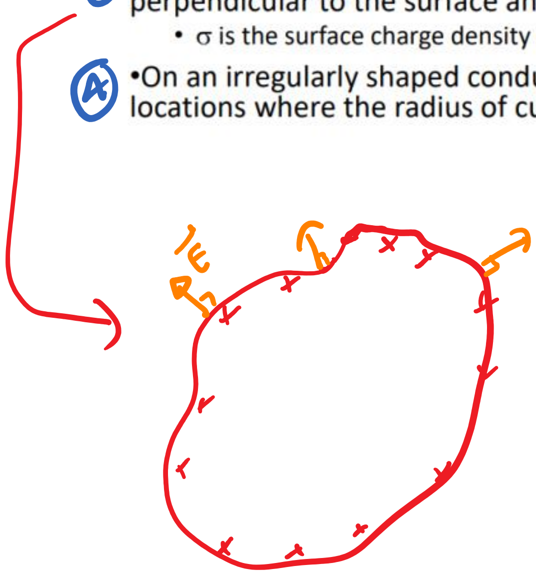
$\Rightarrow 0 = \frac{q_{in}}{\varepsilon_0}$

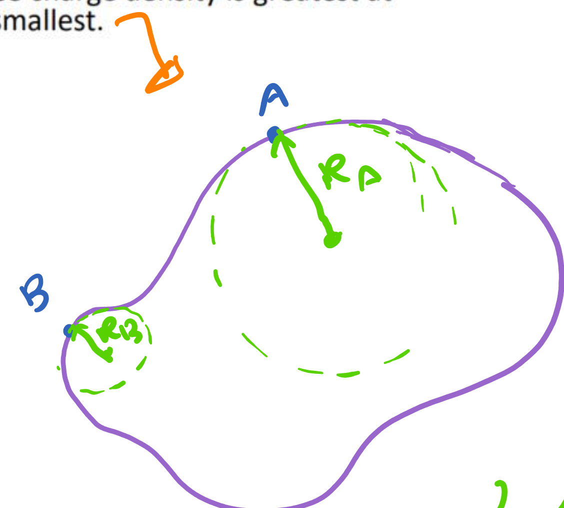
$\Rightarrow q_{in} = 0$

3. The electric field at a point just outside a charged conductor is perpendicular to the surface and has a magnitude of $\sigma/\varepsilon_o$.
    - $\sigma$ is the surface charge density at that point.

$\vec{E} \perp d\vec{A}$

4. On an irregularly shaped conductor, the surface charge density is greatest at locations where the radius of curvature is the smallest.




$R_A > R_B \Rightarrow \sigma_A < \sigma_B$