

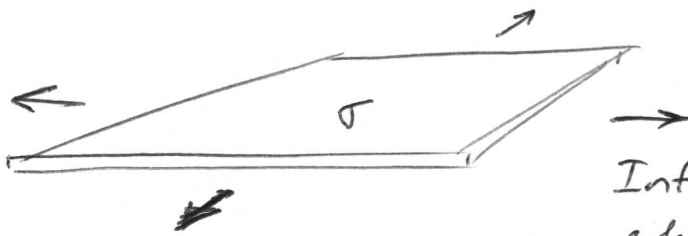
DAY 3

PH 631

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Instructor

Ethan Minot



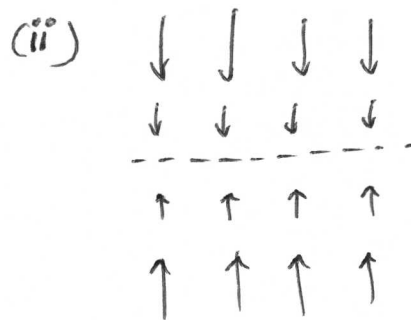
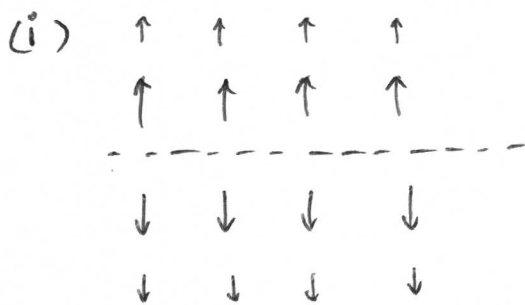
Infinite plate with  
charge density  $\sigma_0$ .  
(charge per unit area)

What symm does  $\rho(\vec{r})$  possess?

- \* Translational symm in x-y plane
- \* Rotational symm around z axis.
- \*  $180^\circ$  flip around x axis or y axis.
- \* Mirror symm about the x-y plane.

Now construct possible  $\vec{E}$ -field patterns that have the same symm as  $\rho(\vec{r})$ .

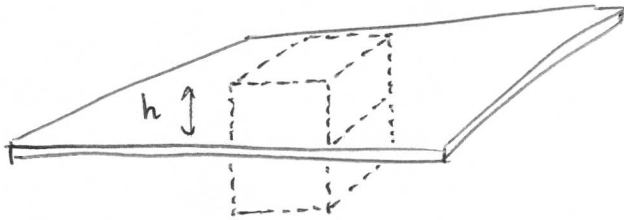
Two candidates are:



- Important features:
- $\vec{E}$  is perpendicular to ~~the~~ plate
  - $\vec{E}$  flips direction above/below the plate.

(2)

Now we use Gauss's Law to find the exact  $\vec{E}(\vec{r})$ .



$$\int_{\text{surf}} \vec{E} \cdot d\vec{a} = \int_{\text{top surf}} \vec{E} \cdot d\vec{a} + \int_{\text{bottom surf}} \vec{E} \cdot d\vec{a} = 2E(h)A$$

↑  
 $h$  is the height  
of the box.

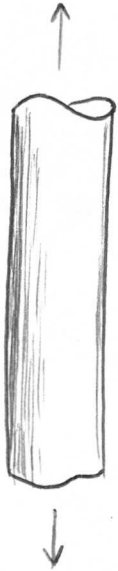
By Gauss's law  $\int_{\text{surf}} \vec{E} \cdot d\vec{a} = \frac{Q_{\text{enc}}}{\epsilon_0}$

$$2EA = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0}$$

independent of  $h$

Name: \_\_\_\_\_



(circular cross-section)

Consider an infinitely long rod that carries a uniform charge density  $\rho_0$ .

- a) What symmetries does  $\rho(\vec{r})$  have?
- b) Draw an  $\vec{E}$ -field that has all the same symmetries as  $\rho(\vec{r})$ .
- c) Draw an  $\vec{E}$ -field that lacks one of the symmetries.

(4)

Application of this result:

## CALCULATING CAPACITANCE

IN GENERAL



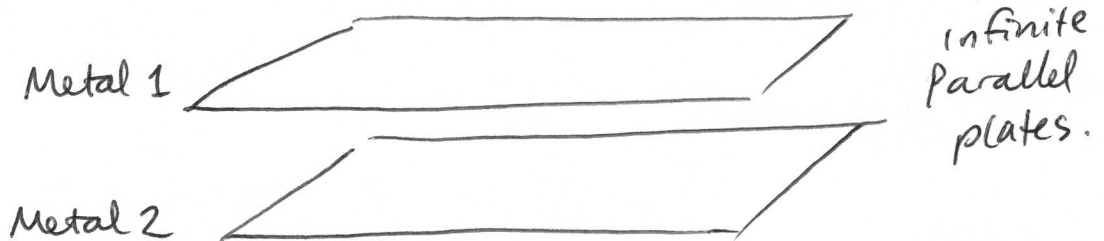
Remember  $\Phi$  is constant inside a conductor.

$$Q = C (\Phi_1 - \Phi_2) = CV$$

↑ this constant of proportionality is called capacitance.

Capacitance calculations are typically started by ~~choosing~~ fixing  $Q$  and then finding  $\Phi_1 - \Phi_2$ .

Example



Step 1: How will the charge distribute?

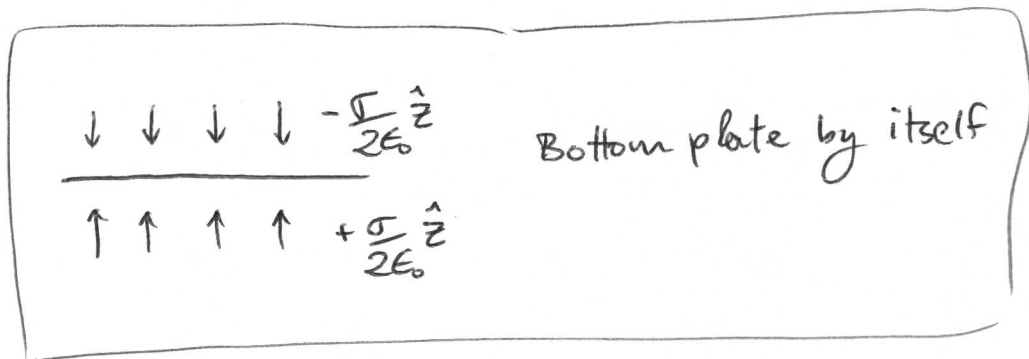
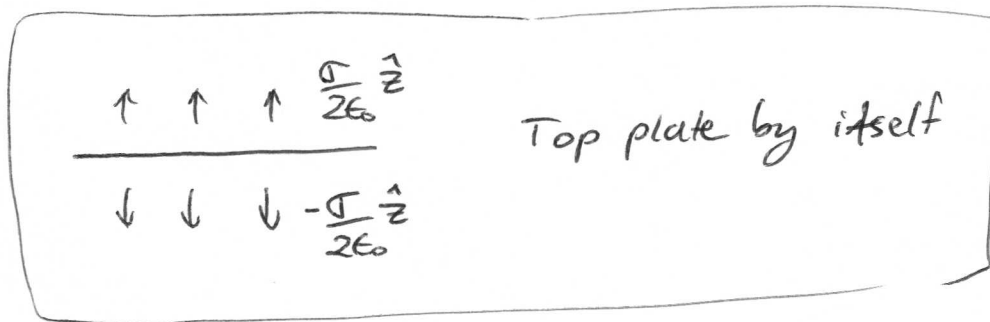
A: The lowest energy state is charge distributed evenly.

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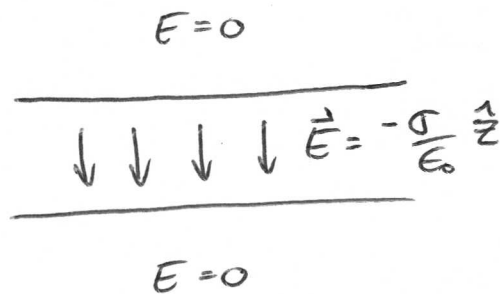
Note: Charge does not always distribute everywhere evenly.



Step 2: Find  $\vec{E}$  field



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Superposition principle.