Gauss's Law III

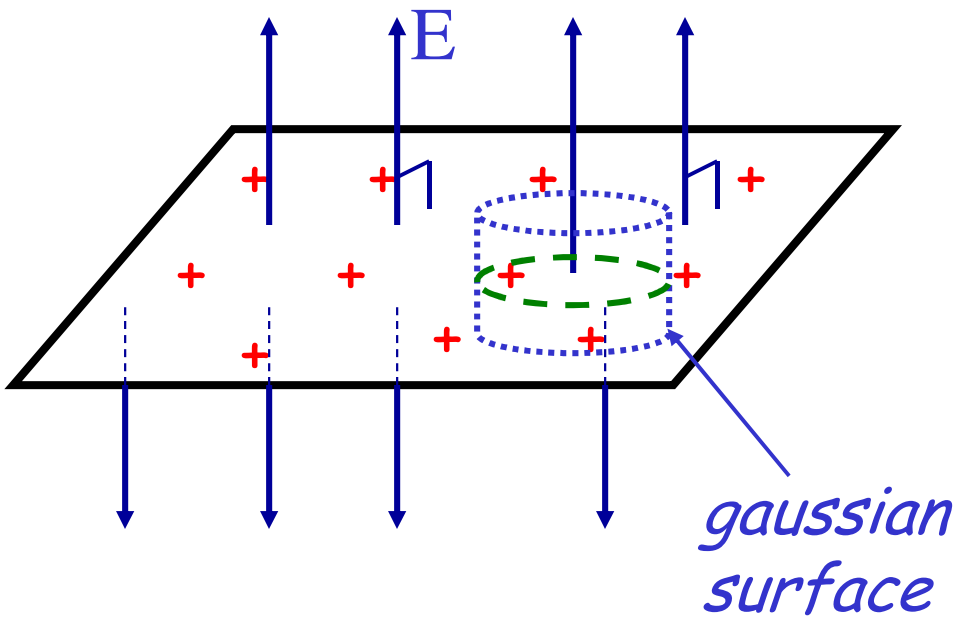
- Uniformly-charged plane
- Conductors in Equilibrium

Text section 24.4

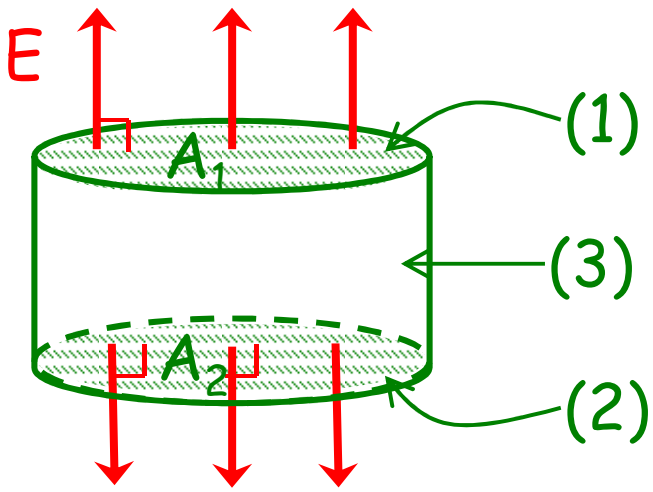
Practice: Chapter 24,
Objective Questions 7, 9
Conceptual Question 8, 10
Problems 39, 41, 54, 56

Uniformly-Charged Thin Sheet

$$\sigma = \frac{\text{charge}}{\text{unit area}}$$ is uniform



(3) Flux:



$\Phi_1 =$

$\Phi_2 =$

$\Phi_3 =$

$\Phi_{TOTAL} =$

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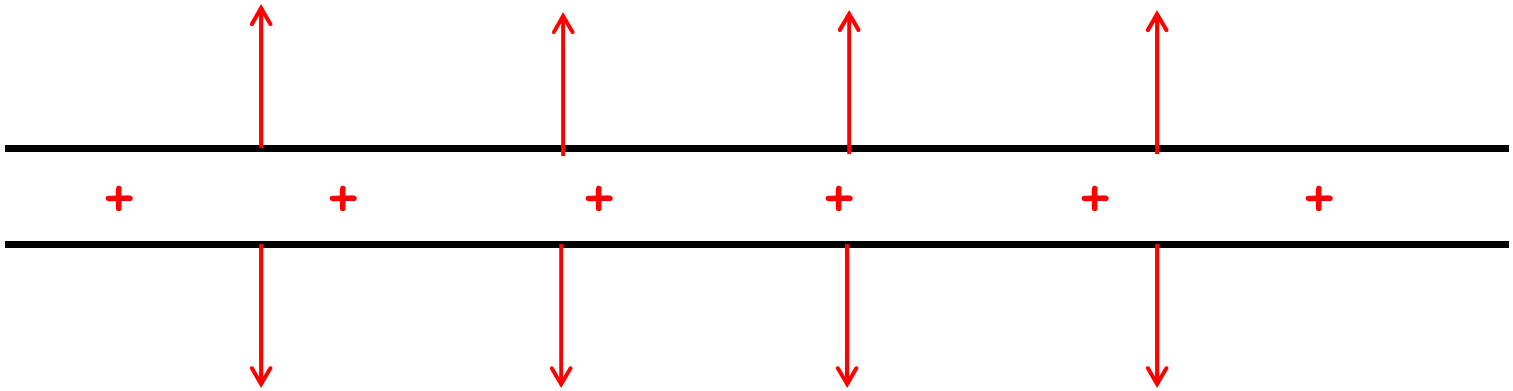
(4) $Q_{enclosed}$ =

Using Gauss's Law…

$$\frac{Q_{enclosed}}{\in_o} = \Phi_E$$

Infinite sheet of charge



Quiz

The electric field 10 cm above an infinite, uniformly-charged plane is 100 N/C. At a point 20 cm above the plane, the field would be

A) zero
B) 100 N/C
C) 50 N/C
D) 25 N/C

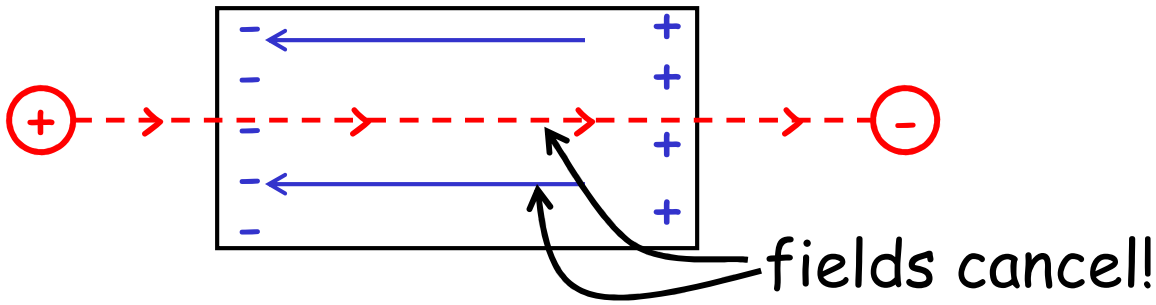
Conductors (in Electrostatic Equilibrium)

1) $\vec{E} = 0$ in a conductor.

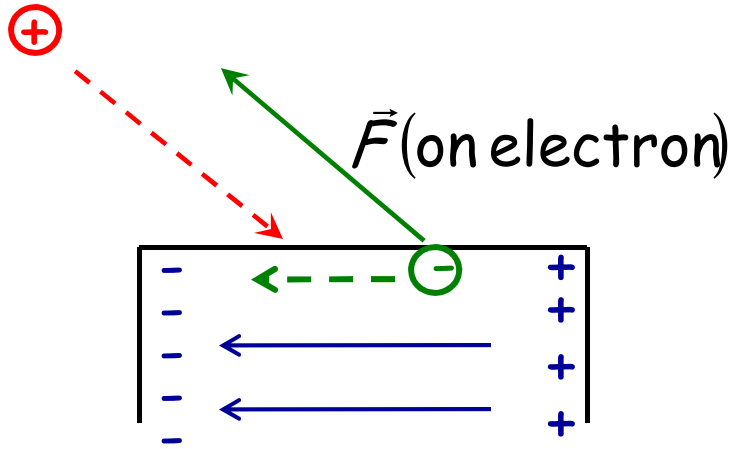
2) $\vec{E} \perp$ *surface* just outside a conductor.

3) Any charge on a conductor is on the surface only.

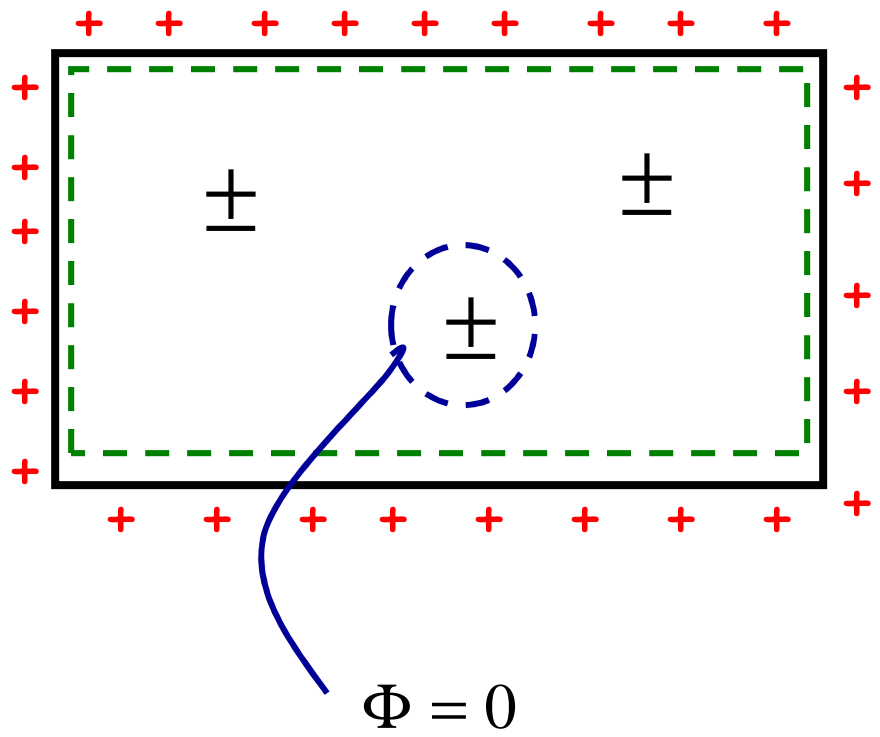
1) If $\vec{E} \neq 0$, charges would move!



2) If $\vec{E}_{||} \neq 0$, charges would move!



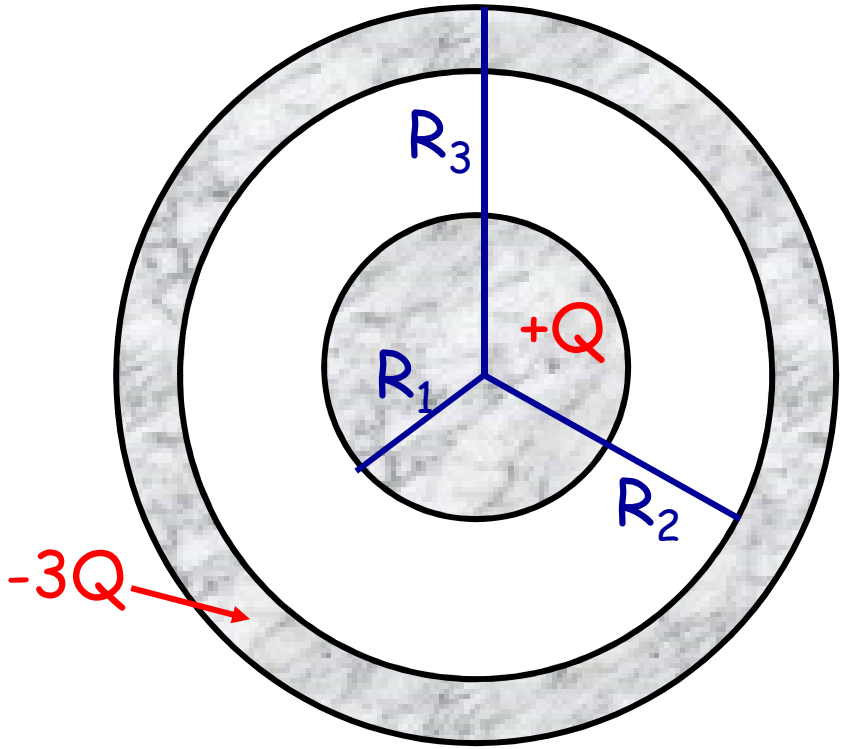
3) $\vec{E} = 0$ inside, so any gaussian surface <u>inside</u> the conductor encloses no net charge.



Since E = 0 <u>everywhere .</u>

Example:

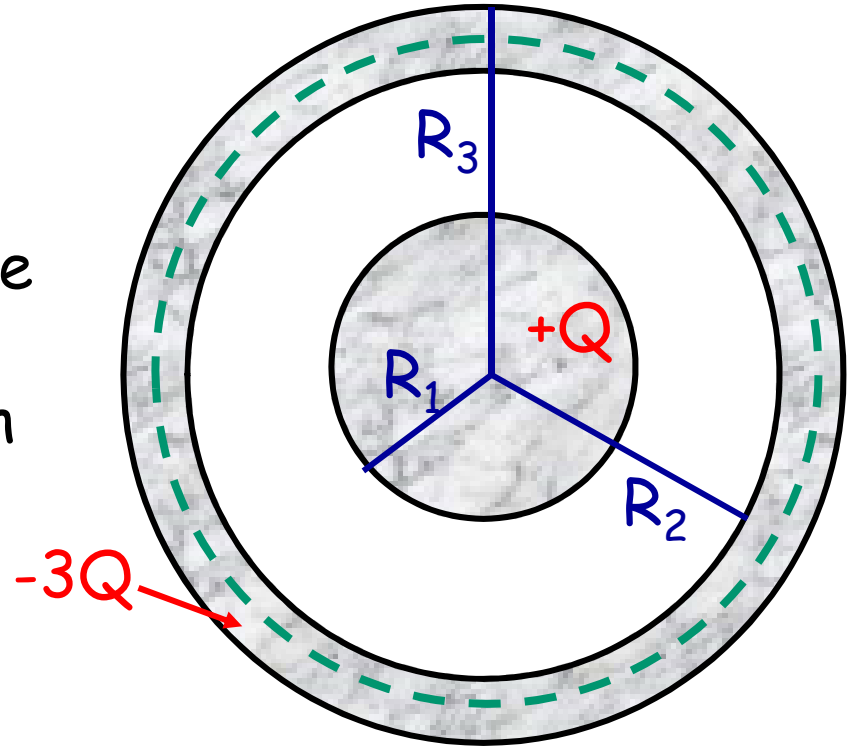
- Metal ball (R_1 ; +Q) with metal shell (R_2, R_3 ; -3Q)
- Find: charges on each surface. (and E)



Quiz:

The dashed green line represents a spherical gaussian surface inside the conducting material. The total electric flux through this surface (in units of Q/ε_0) is

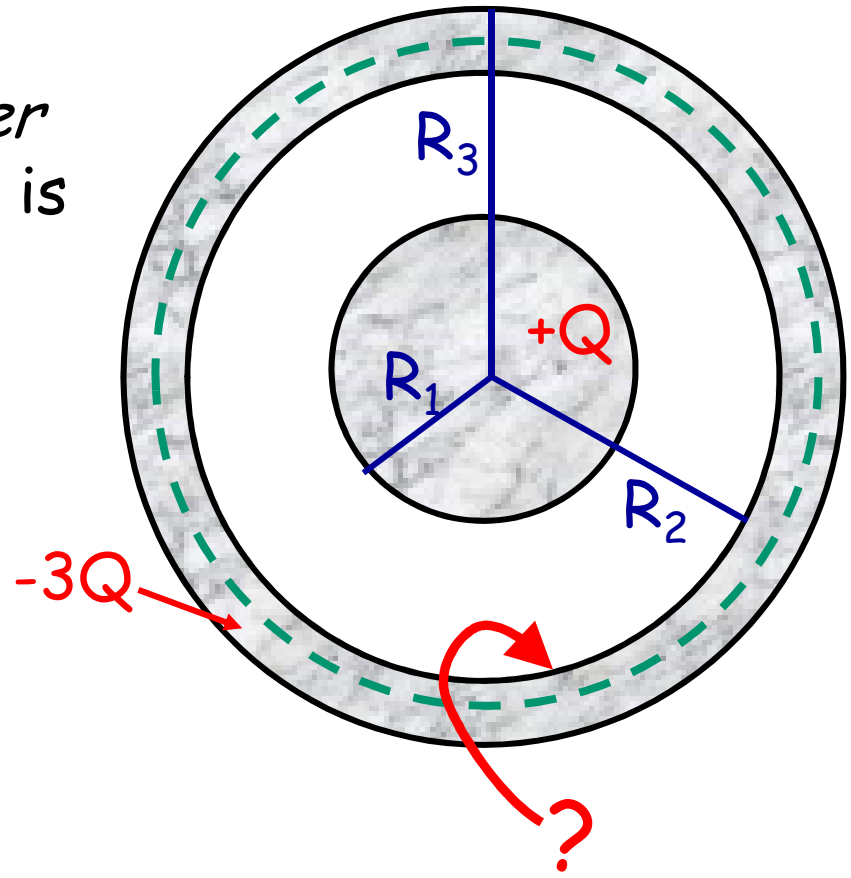
A) 0
B) $-Q/\varepsilon_0$
C) $+Q/\varepsilon_0$
D) $-2Q/\varepsilon_0$
E) $3Q/\varepsilon_0$



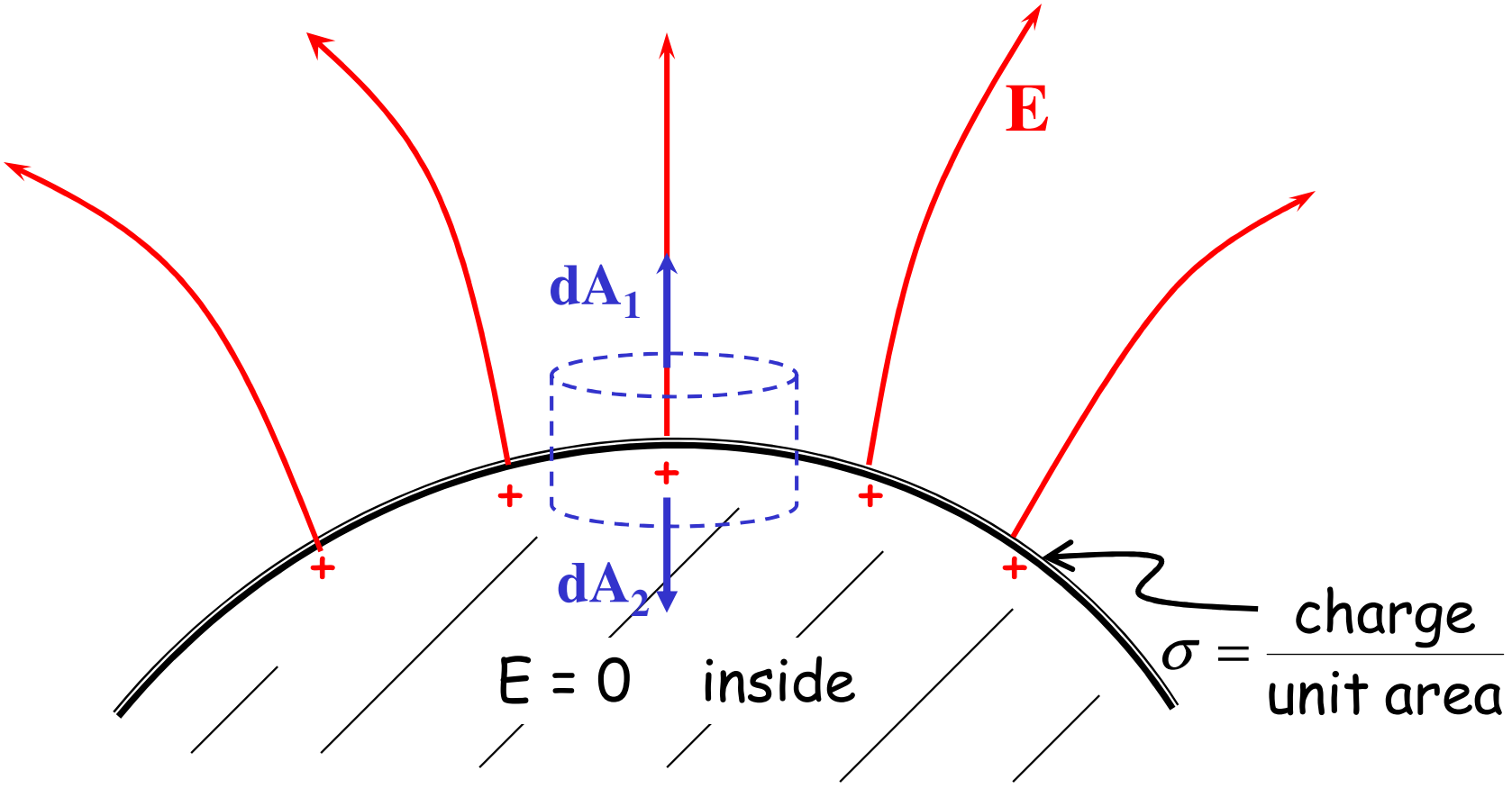
Quiz:

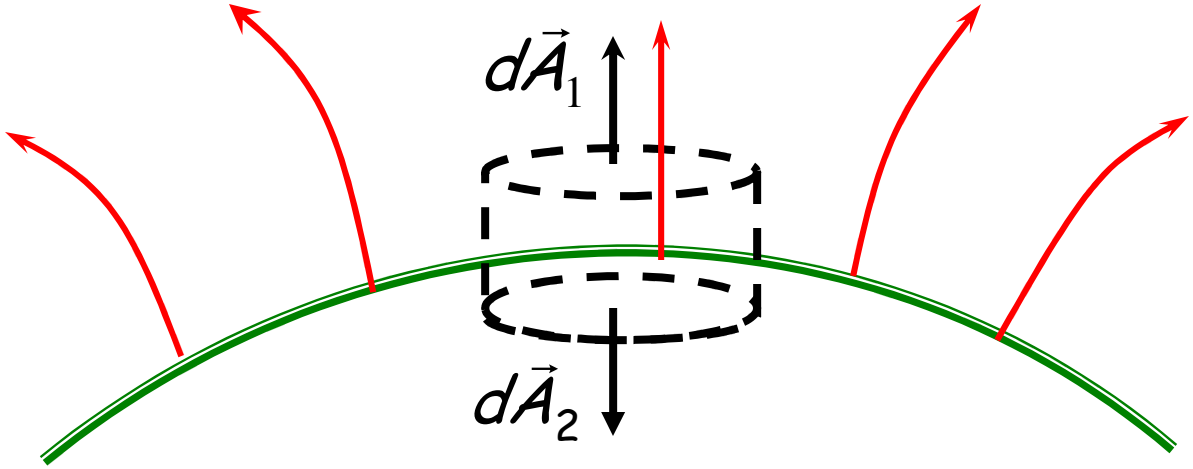
So, the charge on the *inner* surface of the *outer* shell is

A) 0
B) - Q
C) +Q
D) -2Q
E) +3Q



Surface Charge Density on a Conductor





GAUSSIAN SURFACE:

• infinitesimal cylinder with the bottom inside the conductor and the top just outside.

$E \perp top,\ E \parallel$ curved side

FLUX:

- Through top, $d\Phi_1 =$
- Through bottom, $d\Phi_2 =$
- Through curved side, $d\Phi_3 =$
- Total, $d\Phi =$

Charge enclosed, $dQ =$

Using Gauss's Law…

$$\Phi = \frac{Q_{enclosed}}{\varepsilon_o}$$

$$\Rightarrow \quad EdA = \frac{\sigma dA}{\varepsilon_o}$$

$$\Rightarrow \quad \boxed{|\mathbf{E}| = \frac{\sigma}{\varepsilon_o}}$$

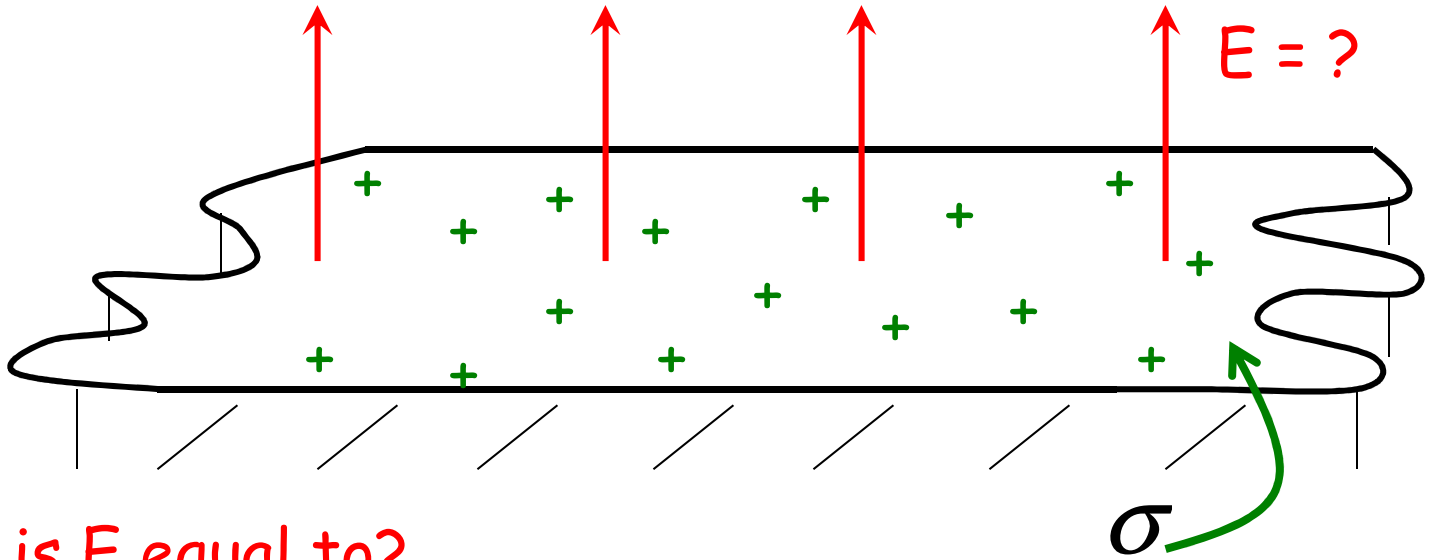
(field just outside conductor)

Quick Recap:

Conductor: $E = \frac{\sigma}{\varepsilon_o}$

Infinite Sheet of charge: $E = \frac{\sigma}{2\varepsilon_o}$

Quiz: Conductor with an infinite flat surface.



What is E equal to?

A) It's the surface of a conductor: $E = \sigma/\varepsilon_0$
B) It's an infinite plane of charge: $E = \frac{1}{2}\sigma/\varepsilon_0$
C) Both of the above.
D) Physics doesn't work.