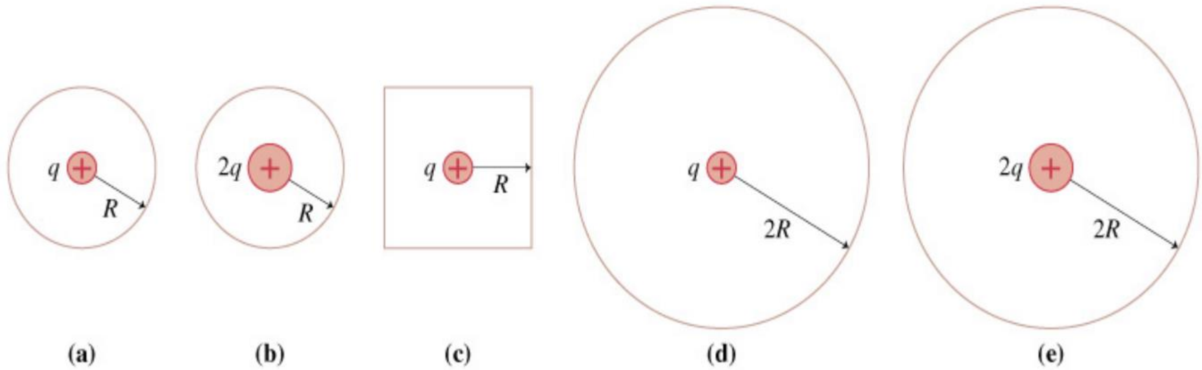
Problem E2.1(☆): Determine the electric flux through each surface below and rank them.



Gauss' Law states that

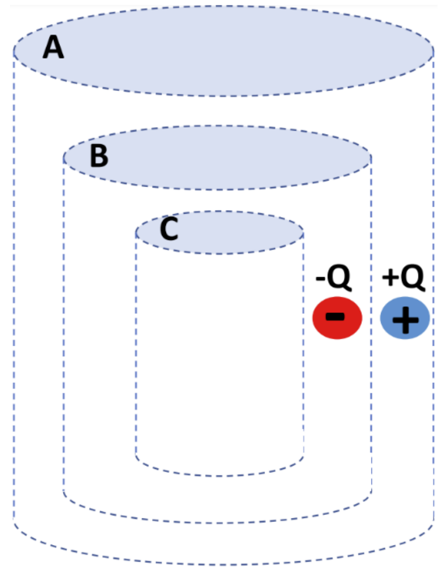
$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

Thus the flux is directly proportional to the enclosed charge. Ranking based on charge, we have:

$$\Phi_a = \Phi_c = \Phi_d = \frac{q}{\varepsilon_0} < \Phi_b = \Phi_e = \frac{2q}{\varepsilon_0}$$

Note that radius is not needed because it is accounted for in the integral of calculating flux from electric field: $\Phi_E = \oint \vec{E} \cdot d\vec{A}$.

Problem E2.2(☆): What is the electric flux through each of the surfaces?



Gauss' Law states that

$$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$$

Thus the flux is only dependant on the charge enclosed.

For surface A:

$$q_{enc} = 0 \Rightarrow \Phi_A = 0$$

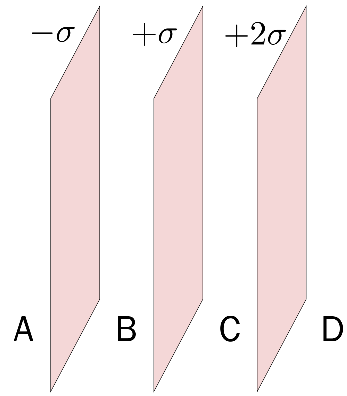
For B:

$$q_{enc} = -Q \Rightarrow \Phi_B = -\frac{Q}{\varepsilon_0}$$

For C:

$$q_{enc} = 0 \Rightarrow \Phi_C = 0 \, .$$

Problem E2.3(☆☆): Three insulating, very large, charged sheets are placed parallel to each other, as shown right, with surface charge densities of $-\sigma$, $+\sigma$, and $+2\sigma$ respectively.



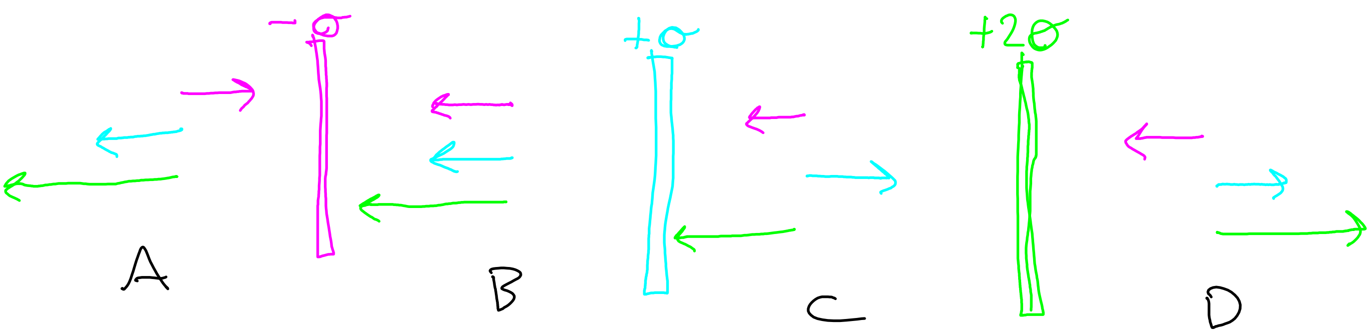
(a) Determine the electric field around the plates, ie at A, B, C, D respectively.

(b) Suppose now the middle sheet was replaced with a conducting sheet that had the same charge density. Would the electric fields in **(a)** change? Why?

(c) What is the surface charge density on the left and right surfaces of the conductive sheet?

We derived in class that the electric field of an infinite plane was: $\vec{E} = \frac{\sigma}{2\varepsilon_0}$ (independent of d!)

(a) Hence, main task is to work out vectors:

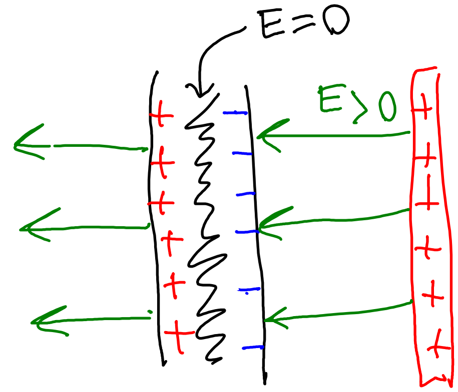


$$\therefore \vec{E}_A = -\frac{\sigma}{\varepsilon_0}\hat{x} \qquad \vec{E}_B = -2\frac{\sigma}{\varepsilon_0}\hat{x}$$

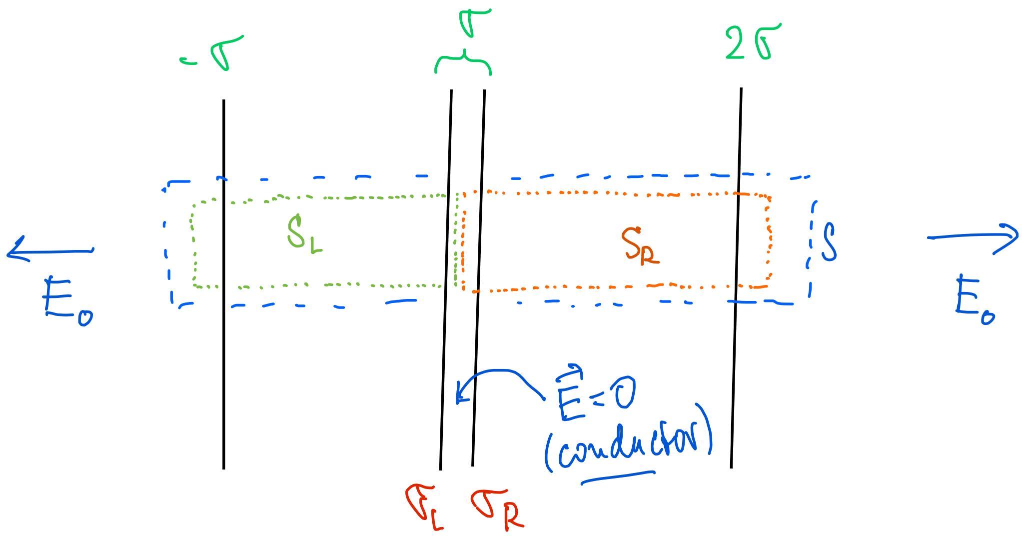
$$\vec{E}_C = -\frac{\sigma}{\varepsilon_0}\hat{x} \qquad \vec{E}_D = +\frac{\sigma}{\varepsilon_0}\hat{x}$$

(b) The E-field inside a conductor must be 0. Charges would accumulate on the surface of the conductor to cancel the fields from the other planes. But this charge separation would produce

(b) cont... an identical distribution on the other side of the conductor. Thus, the conductor will create 'mirror images', so the E-fields <u>won't change</u>!



(c)



Consider 3 gaussian surfaces S, S_L and S_R

S: $\quad 2E_0 = (-\sigma + \sigma + 2\sigma)/\varepsilon_0 = \dfrac{2\sigma}{\varepsilon_0}, \quad E_0 = \dfrac{\sigma}{\varepsilon_0}$

S_L: $\quad E_0 = (-\sigma + \sigma_L)/\varepsilon_0$

$\quad \rightarrow \quad \sigma_L = \varepsilon_0 E_0 + \sigma = 2\sigma$

S_R: $\quad E_0 = (\sigma_R + 2\sigma)/\varepsilon_0$

$\quad \rightarrow \quad \sigma_R = \varepsilon_0 E_0 - 2\sigma = -\sigma$

Hence $\boxed{\sigma_L = 2\sigma, \quad \sigma_R = -\sigma}$