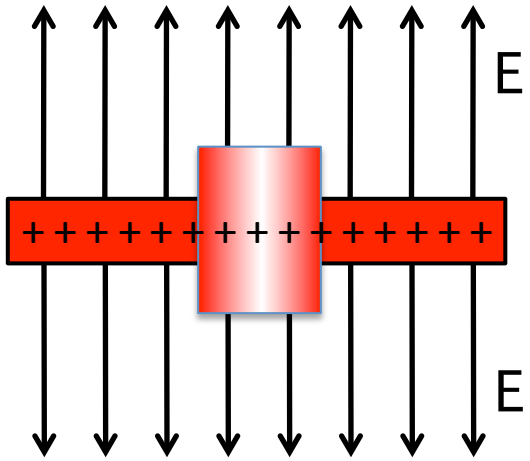
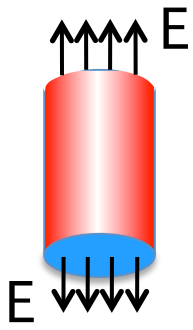
Problem 24.23

Consider a flat, horizontal sheet of charge of area charge density $\sigma = 9.0\text{x}10^{-6}\text{C/m}^2$. What is the electric field intensity just above the middle of the plate?

There are two ways to do this. The hard way is to use a Gaussian plug (see sketch below) that extends the same distance on either side of the plate, and use Gauss's Law on that plug.

Side view with exaggerated thickness and E-fld lines





Gaussian plug with field lines passing through it and end-cap area of "A"

Noting that all of the flux will pass through the two end-caps; noting that flux through one end-cap is EA, where A is the area of the end-cap; and noting that the amount of charge enclosed inside the Gaussian surface is the *charge per unit area* σ times the area of the portion of the plate inside the Gaussian surface, or A, we get:

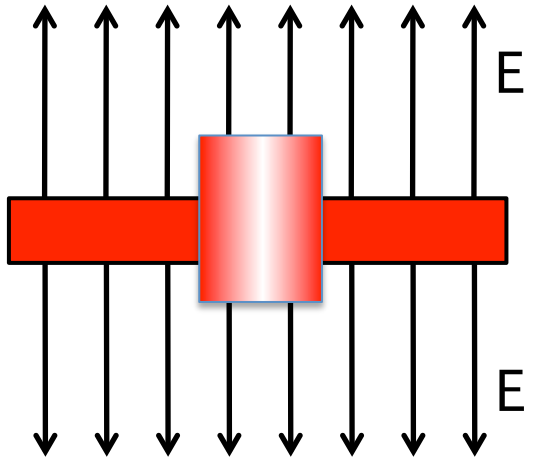
$$\int_A E\,dA = \frac{q_{enc}}{\varepsilon_o}$$

$$\Rightarrow \quad EA + EA = \frac{\sigma A}{\varepsilon_o}$$

$$\Rightarrow \quad E = \frac{\sigma}{2\varepsilon_o}$$

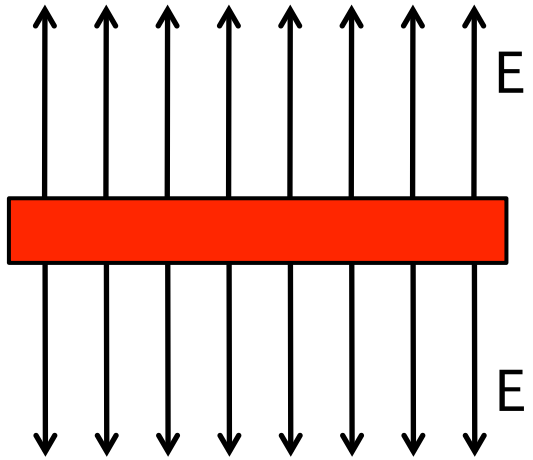
$$= \frac{\left(9 \times 10^{-6} C/m^2\right)}{2\left(8.85 \times 10^{-12} C^2/N \bullet m^2\right)}$$

$$= 5.08 \times 10^5 \; N/C$$



The easy way to determine this electric field function is to know that the electric field function for an insulating sheet of charge is:

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



Q.E.D.