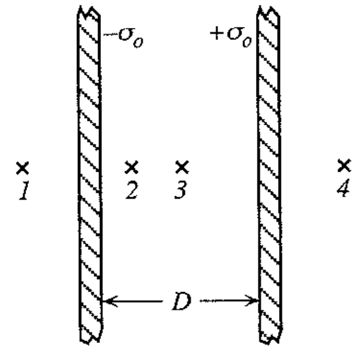
II. Parallel plates and capacitance

Two very large thin conducting plates are a distance D apart. The surface area of the face of each plate is A_o. A side view of a small portion near the center of the plates is shown.



A. The inner surface of one plate has a uniform charge density of $+\sigma_o$; the other, $-\sigma_o$. The charge density on the outer surface of each plate is zero.

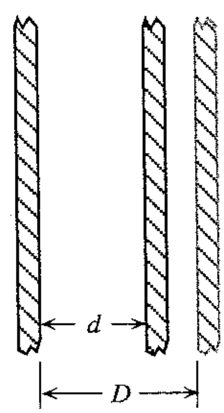
1. At each labeled point, draw vectors to represent the electric field at that point due to each charged plate.

2. Write expressions for the following quantities in terms of the given variables:

   - the electric field at points *1*, *2*, *3*, and *4*

   - the potential difference between the plates

3. The right plate is moved to the left as shown. Both plates are kept insulated. Describe how each of the following quantities will change (if at all). Explain.



   - the charge density on each plate

   - the electric field both outside and between the plates

   - the potential difference between the plates

4. Write expressions for the following quantities in terms of σ_o and d (the new distance between the plates).

   - the magnitude of the electric field between the plates

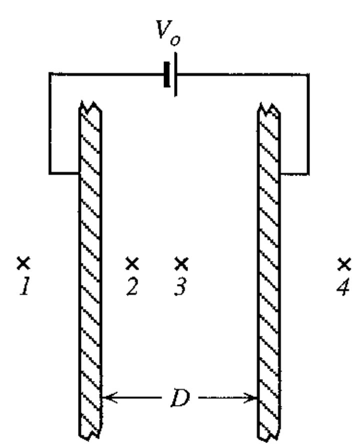
   - the potential difference between the plates

5. Find $\frac{Q}{\Delta V}$ (the ratio of the net charge on one plate to the potential difference between the plates).

   How, if at all, would this ratio change if the charge densities on the plates were $+2\sigma_o$ and $-2\sigma_o$?

➪ Check your results for part A with a tutorial instructor before you continue.

B. Suppose the plates are discharged, then held a distance D apart and connected to a battery. (Ignore the fringing fields near the plate edges.)



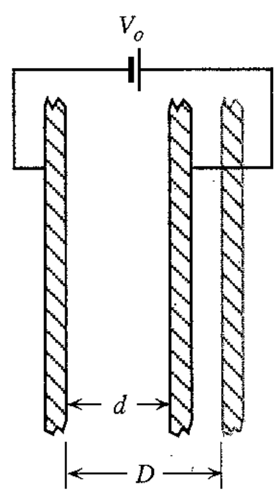
1. Write expressions for the following quantities in terms of the given variables. Explain your reasoning in each case.

   - the potential difference ΔV between the plates

   - the electric field at points *1*, *2*, *3*, and *4*

   - the charge density on each plate

2. The right plate is moved to the left. Describe how each of the following quantities changes (if at all). Explain.



   - the potential difference ΔV between the plates

   - the electric field both outside and between the plates

   - the charge density on each plate

3. Write expressions for the following quantities in terms of V_o and d (the new distance between the plates).

   - the magnitude of the electric field between the plates

   - the charge density on each plate

4. Find $\frac{Q}{\Delta V}$ (the ratio of the net charge on one plate to the potential difference between the plates).

   How, if at all, would this ratio change if the voltage of the battery was $2V_o$?

➪ Check your results for part B with a tutorial instructor before you continue.

C. Compare the ratio $\frac{Q}{\Delta V}$ that you calculated for two insulated plates (part A) to the same ratio for two plates connected to a battery (part B).

1. Does the ratio $\frac{Q}{\Delta V}$ depend on whether or not the plates are connected to a battery?

2. Does the ratio $\frac{Q}{\Delta V}$ depend on the distance between the plates?

The potential difference ΔV between two isolated conductors depends on their net charges and their physical arrangement. If the conductors have charge $+Q$ and $-Q$, the ratio $\frac{Q}{\Delta V}$ is called the *capacitance (C)* of the particular arrangement of conductors.

D. For the following cases, state whether each of the quantities q, σ, E, ΔV, and C changes or remains fixed:

1. two insulated conducting plates are moved farther apart

2. two conducting plates connected to a battery are moved farther apart