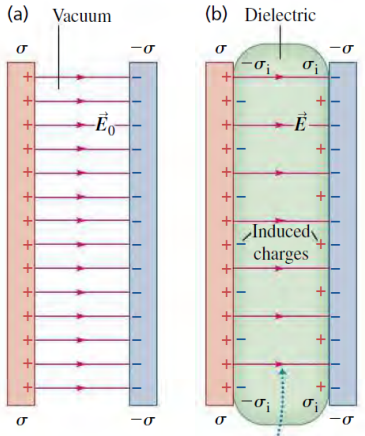
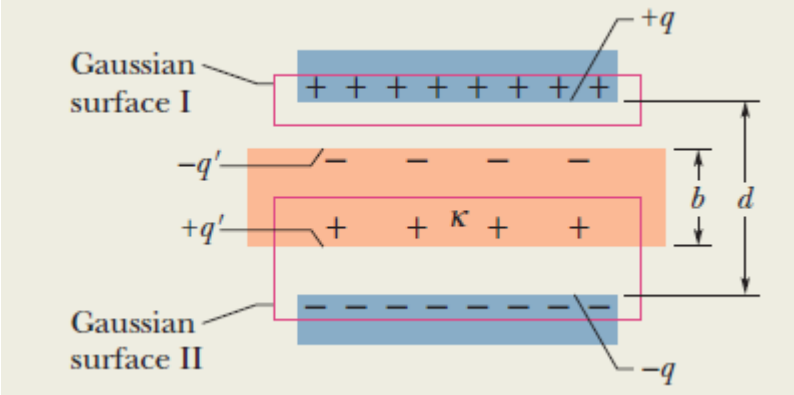
Capacitance Problems

1. Suppose that the parallel plates in the figure below each have an area of $2000cm^2$ and are $1.00cm$ apart. We connect the capacitor to a power supply, charge it to a potential difference $V_0 = 3.00kV$, and disconnect the power supply. We then insert a sheet of insulating plastic material between the plates, completely filling the space between them. We find that the potential difference decreases to $1.00kV$ while the charge on each capacitor plate remains constant. Find (a) the original capacitance C_0; (b) the magnitude of charge q on each plate; (c) the capacitance C after the dielectric is inserted; (d) the dielectric constant K of the dielectric; (e) the permittivity ϵ of the dielectric; (f) the magnitude of the induced charge q_i on each face of the dielectric; (g) the original electric field E_0 between the plates; and (h) the electric field E after the dielectric is inserted. (i) Find the energy stored in the capacitor's electric field, and the energy density, both before and after the dielectric sheet is inserted.

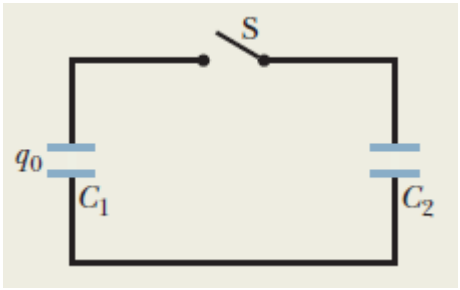


For a given charge density σ, the induced charges on the dielectric's surfaces reduce the electric field between the plates.

2. The figure below shows a parallel-plate capacitor of plate area A and plate separation d. A potential difference V_0 is applied between the plates by connecting a battery between them. The battery is then disconnected, and a dielectric slab of thickness b and dielectric constant k is placed between the plates as shown. Assume $A = 115cm^2$, $d = 1.24cm$, $V_0 = 85.5V$, $b = 0.780cm$, and $k = 2.61$. (a) What is the capacitance C_0 before the dielectric slab is inserted? (b) What free charge appears on the plate? (c) What is the electric field E_0 in the gaps between the plates and the dielectric slab? (d) What is the electric field E_1 in the dielectric slab? (e) What is the potential difference between the plates after the slab has been introduced? (f) What is the capacitance with the slab in place?



3. Capacitor 1, with $C_1 = 3.55\mu F$, is charge to a potential difference $V_0 = 6.30V$, using a $6.30V$ battery.The battery is then removed, and the capacitor is connected as in the figure below to an uncharged capacitor 2, with $C_2 = 8.95mF$. When switch S is closed, and charge flows between the capacitors. Find the charge on each capacitor when equilibrium is reached.



4. In the figure below, a $20.0V$ battery is connected across capacitors of capacitances $C_1 = C_6 = 3.00\mu F$ and $C_3 = C_5 = 2.00C_2 = 2.00C_4 = 4.00\mu F$.What are (a) the equivalent capacitance C_{eq} of the capacitors and (b) the charge stored by C_{eq}? What are (c) V_1 and (d) q_1 of capacitor 1, (e) V_2 and (f) q_2 of capacitor 2, and (g) V_3 and (h) q_3 of capacitor 3?