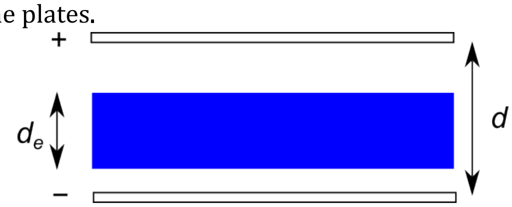
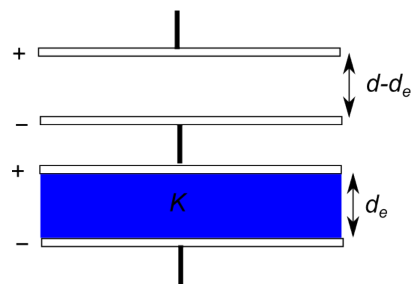
1. The plates of a parallel-plate capacitor have an area of 10.0 $cm^2$ and are separated by a distance of 0.30 cm. A potential difference of 180V is applied between the plates.
   a. How much charge is stored in the capacitor?
   b. What is the strength of the electric field between the plates?
   c. How much energy is stored in the capacitor?

2. Repeat problem #1 for the case when the gap between the plates is filled with barium strontium titanate, which has a dielectric constant of 500.

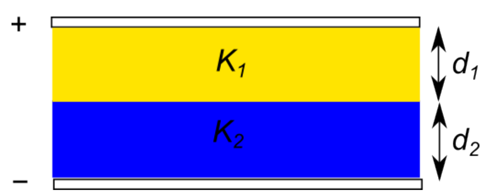
3. The plates of a parallel-plate capacitor are separated by distance $d$, and an insulating slab with a thickness $d_e$ and dielectric constant $K$ is inserted between the plates. The area of the plates is $A$. Assume that $d > d_e$ but not that the slab is centered between the plates.
   a. Calculate the capacitance of the capacitor.
   b. Show that if the dielectric fills the gap between the plates, then the capacitance you found in part a) becomes $KC_0$, where $C_0$ is the capacitance with no dielectric.
   c. Determine the strength of the electric field everywhere between the plates (both in the vacuum and in the dielectric) if a potential $\Delta V$ is applied across the plates.
   d. Determine the total energy stored in the capacitor.




4. Show that the capacitance and energy you found in problem 3 is the same as for the case of two parallel-plate capacitors in series, both of which have plates of area $A$, and where the plates of the first capacitor are separated by a vacuum of thickness $d-d_e$ and the plates of the second capacitors are separated by a thickness $d_e$ that is filled with a material of dielectric constant $K$.



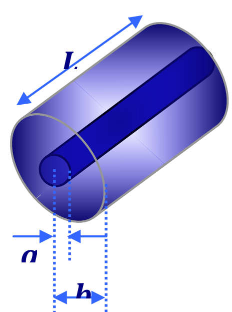

5. You have a parallel-plate capacitor of area $A$ and a gap of thickness $d$ that is filled with a two-layer dielectric. The first layer of the dielectric has a thickness $d_1$ and dielectric constant $K_1$ and the second layer of the dielectric has a thickness $d_2$ and dielectric constant $K_2$.
   a. Calculate the capacitance (hint: you can treat this as two capacitors in series).
   b. Calculate the electric field strength in each layer.
   c. Calculate the energy density in the electric field in each layer.

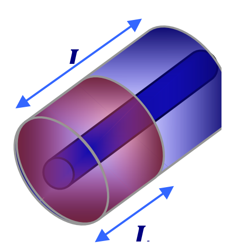



6. A capacitor consists of wire of length $L$ and radius $a$, and a coaxial, conducting, cylindrical shell that has radius $b$ and also has length $L$, as shown in the first diagram. Charge $+q$ is placed on the inner wire. Express your results in terms of given quantities and fundamental quantities only.
   a. Determine the electric field between the wire and the shell.
   b. Determine the potential difference between the wire and the shell.
   c. Determine the capacitance of the device, $C_0$.

   A dielectric material with $\kappa = 4$ is placed between the wire and the shell such that it fills only the front half of the space, as shown in the second diagram.

   d. Determine the capacitance of the new device in terms of $C_0$.



7. A capacitor consists of two parallel plates of area $A$, separated by distance $d$. The capacitor is charged to potential $V$ with the polarity of the charge as shown. Only air ($\kappa = 1$) is between the plates of the capacitor. Answer the following in terms of given quantities and fundamental constants.
   a. Determine:
      i. the charge on the capacitor
      ii. the electric field between the capacitor plates
      iii. the energy stored in the capacitor

   Now suppose the plates are further separated to a distance of $3d$. The plates are isolated so that no charge is lost during the process.
   b. Find:
      i. the new value of capacitance.
      ii. the new potential difference across the capacitor
      iii. How much energy is stored in the capacitor.
      iv. How much work was done to separate the plates.

   Finally, suppose the plates are returned to a separation $d$. The plates are isolated so that no charge is lost during the process. Now, a metal block having area $A$ and thickness $b < d$, is placed midway between the plates as shown. The capacitor is isolated so that no charge is lost in the process.


   c. What is the electric field within the block?
   d. What must be the charge on the top surface of the block?
   e. What must be the charge on the bottom surface of the block?
   f. What is the potential difference between the top plate and the top surface of the block?
   g. Find the capacitance of the new arrangement.
   h. How much energy is stored in the new capacitor?
   i. Was positive or negative work done in inserting the block?
   j. Give an explanation involving forces, not energy, of why the sign of the work done in inserting the block is as you say in part i.