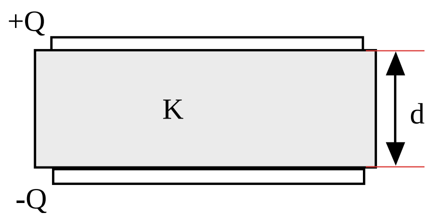
Atomic Description of Dielectrics

We have seen experimentally that when a dielectric is inserted between the plates of a capacitor:

1. V decreases by a factor of 1/K ($V = V_o/k$)
2. C increases by a factor of K ($C = KC_o$)

We haven't yet explained what causes these effects and it is what we will now do. First, let's see what happens to the E-field when a dielectric is placed between the plates of a capacitor.



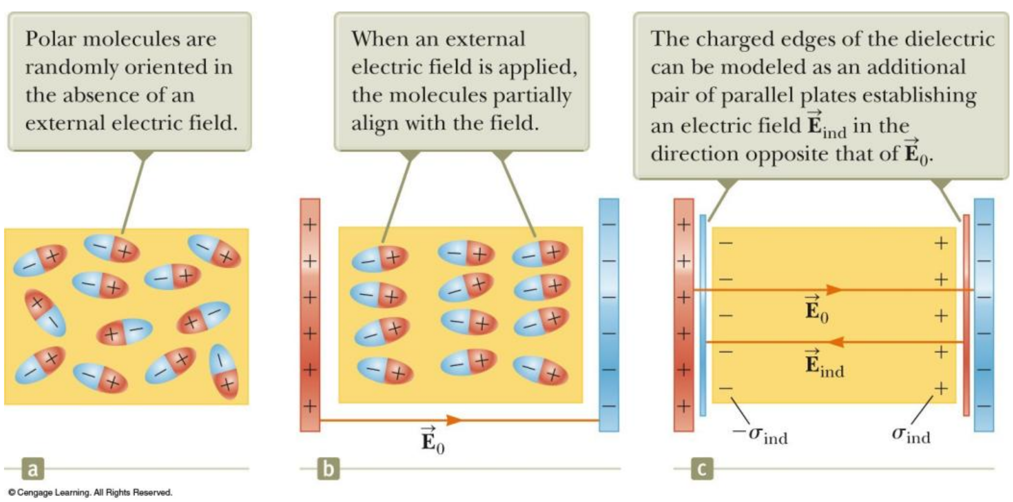
$$V_o = E_o d$$

$$E_o = \frac{V_o}{d}$$

$$E = \frac{V}{d} = \frac{V_o / K}{d} = \frac{1}{K}\frac{V_o}{d} = \frac{E_o}{K}$$

$$\boxed{E = \frac{E_o}{K}}$$

Thus, **E** also decreases by a factor of 1/K. The decrease in **E** is what actually causes V to decrease and C to increase. To explain why E decreases we need to look at the dielectric at the atomic level.



When the dielectric is not placed in an external electric field $\mathbf{E_o}$ the electric dipoles are oriented randomly in different directions as shown in (a). When the dielectric is placed in an external E-field the electric dipoles experience a torque that will align them with the E-field as shown in (b). The dielectric is now polarized. The result is that the external E-field induces a positive surface charge density on the right and negative surface charge density on the left as shown in (c). This induced charge gives rise to an induced electric field $\mathbf{E_{ind}}$ that opposes the external field $\mathbf{E_o}$. Since **E** decreases, then we can add more charge to capacitor before reaching dielectric breakdown. Since we can store more charge, and thus more energy, the capacitance increases.