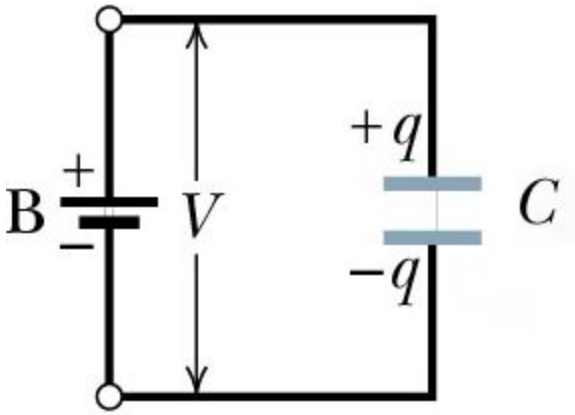
Capacitance



- Parallel-plate capacitor charged to potential *V* by battery
- Disconnect battery to have an isolated system
- If the distance, *d*, between the plates is decreased what happens to *C*?

LARGER

- What happens to *V* ?

Isolated system *q* stays same so *V* decreases if *C* increases

$$C = \frac{\varepsilon_0 A}{d}$$

$$V = \frac{q}{C}$$

Capacitance

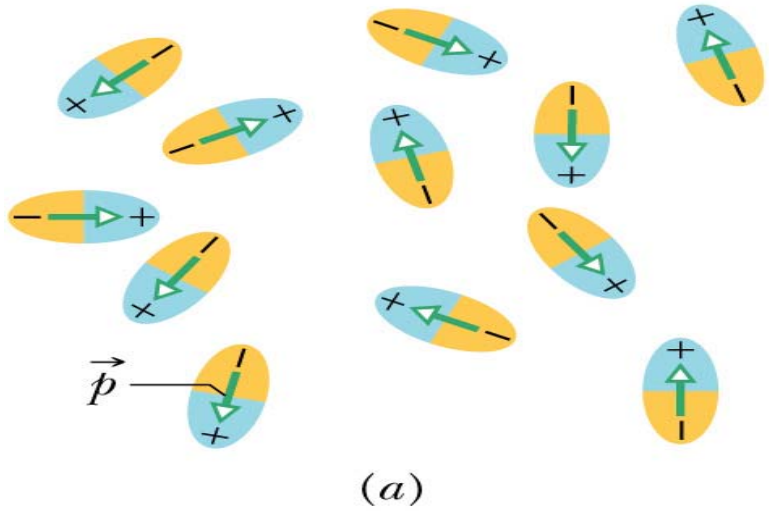
- Observe what happens if I put material between the plates?
- *V* decreases

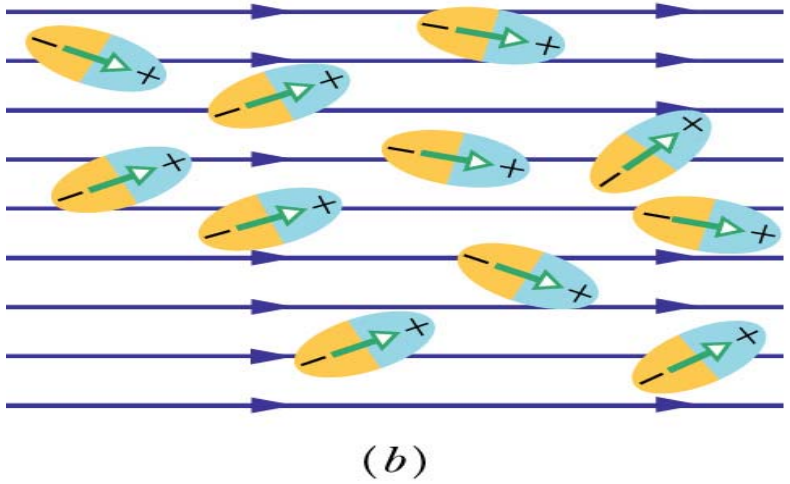
$$C = \frac{q}{V}$$

- so *C* must increase – why?

Dielectric

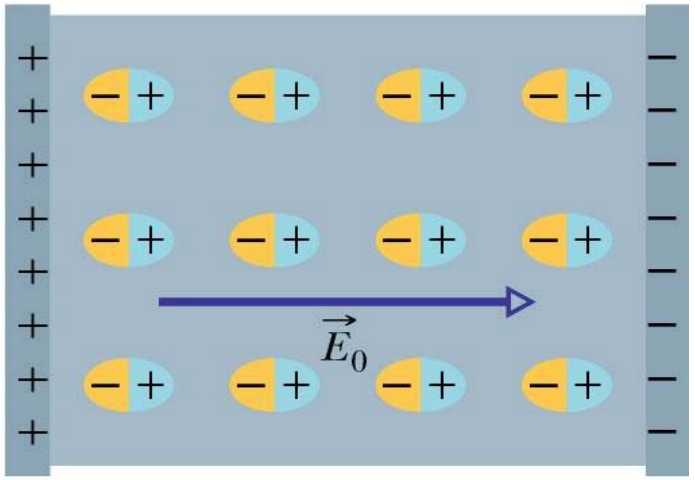
- Why does C increase if add material?
- Material made up of molecules which are dipoles
- Molecules align with E field from capacitor



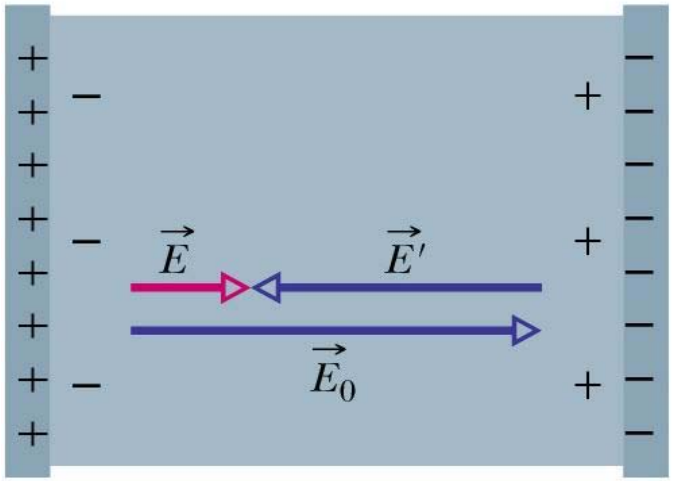


Dielectric

- Dipoles set up field E' which opposes capacitors field E_o
- Total field E is smaller than original E_o
- Material is called a dielectric



(b)



(c)

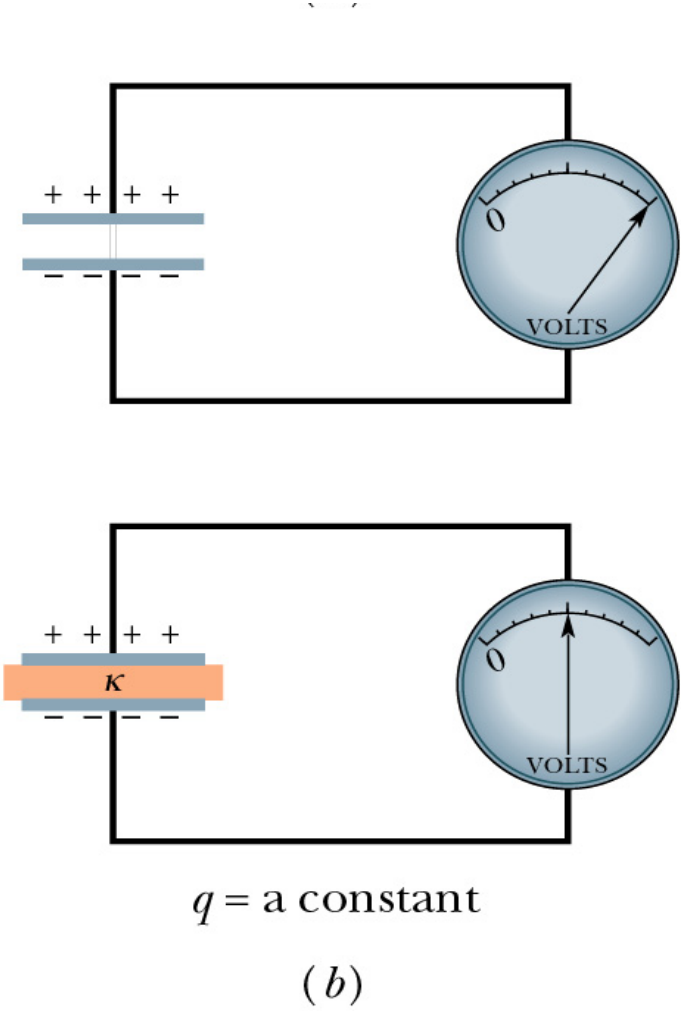
Dielectric

$$V = Ed$$

- E field is weaker so V decreases

$$C = \frac{q}{V}$$

- q is constant so C INCREASES



Dielectric

- Place a dielectric in capacitor its capacitance increases by numerical factor.
- Called dielectric constant, κ

$$C_{dielectric} = \kappa C_{air}$$

Some Properties of Dielectrics[a]

Material	Dielectric Constant κ	Dielectric Strength (kV/mm)
Air (1 atm)	1.00054	3
Polystyrene	2.6	24
Paper	3.5	16
Transformer oil	4.5	
Pyrex	4.7	14
Ruby mica	5.4	
Porcelain	6.5	
Silicon	12	
Germanium	16	
Ethanol	25	
Water (20°C)	80.4	
Water (25°C)	78.5	
Titania ceramic	130	
Strontium titanate	310	8

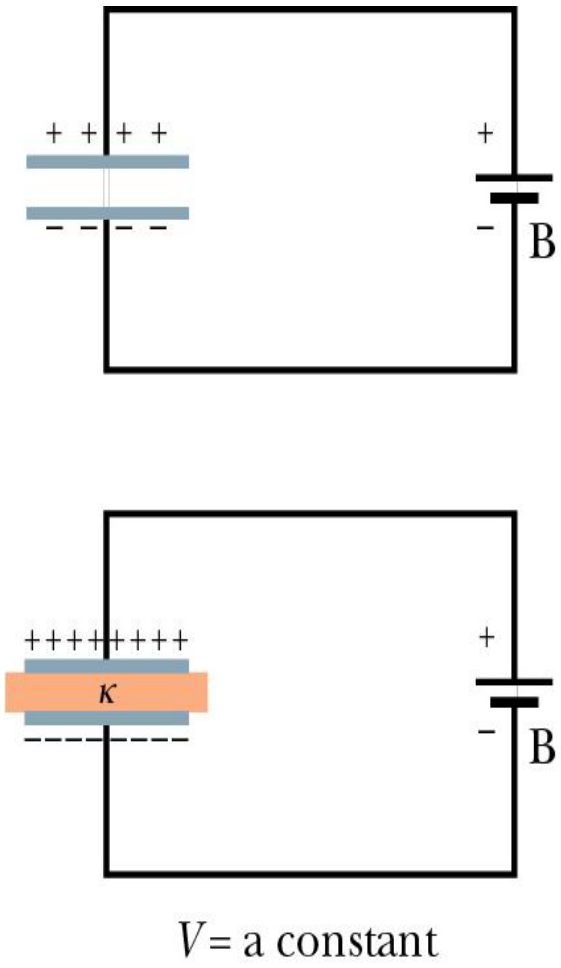
For a vacuum, κ = unity.

[a]Measured at room temperature, except for the water.

Dielectric

- If system is connected to a battery, V is a constant
- C increases with dielectric so q must increase

$$q = CV$$



V = a constant