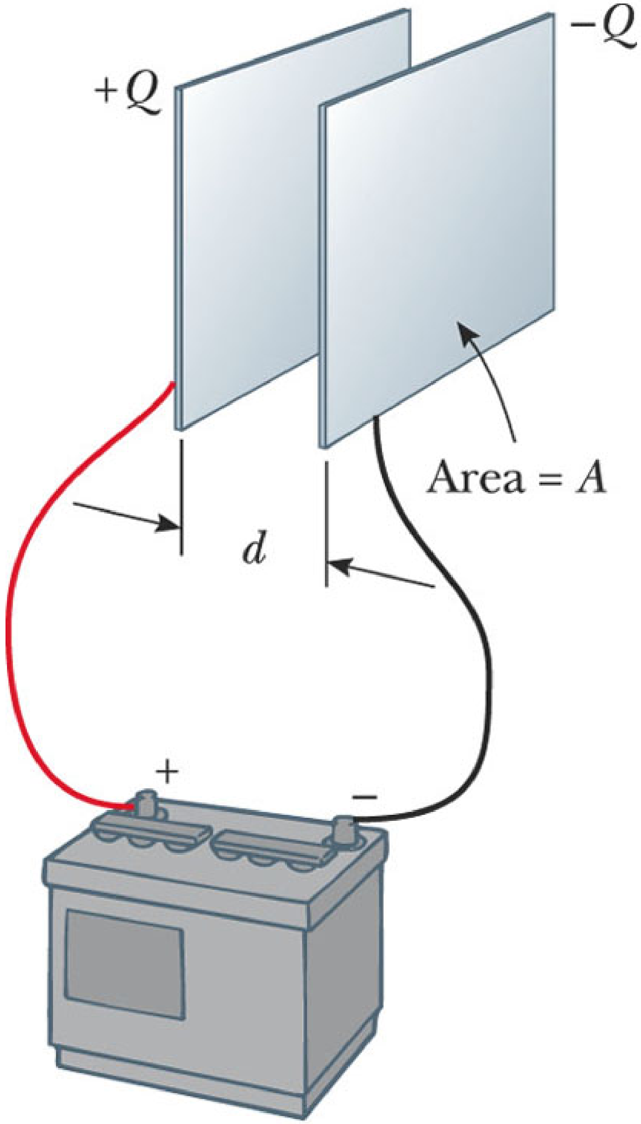
A Capacitor

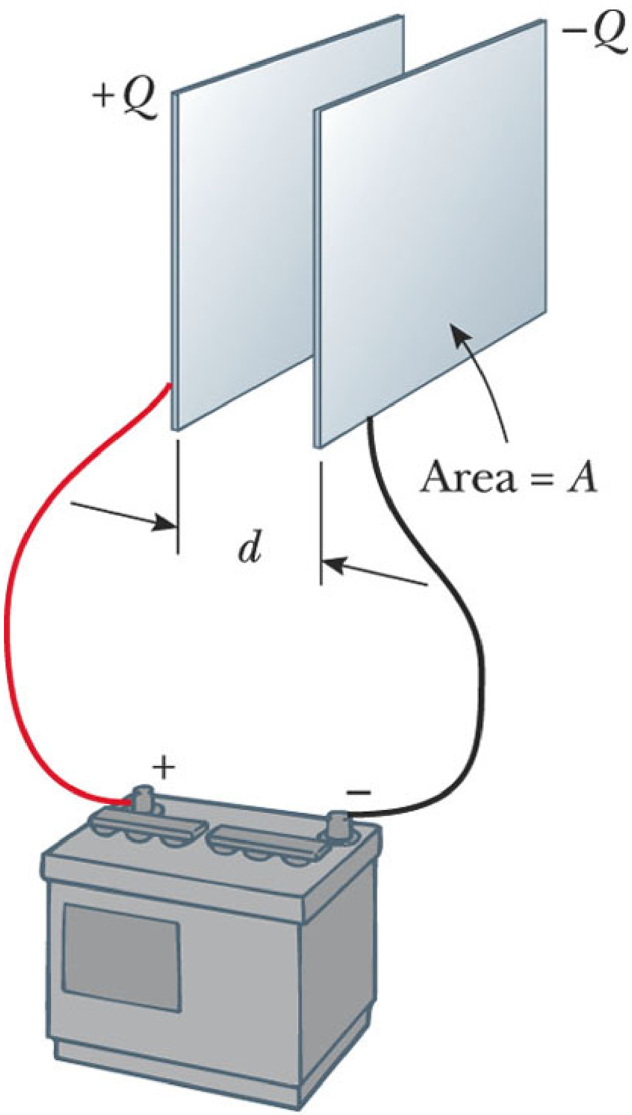


Note: +Q plate is connected to positive terminal of battery; –Q plate connected to – terminal.

Capacitance is defined as the ability to store separated charge.

$C = Q / \Delta V$

Unit: FARAD = C/V



Parallel Plate Capacitor

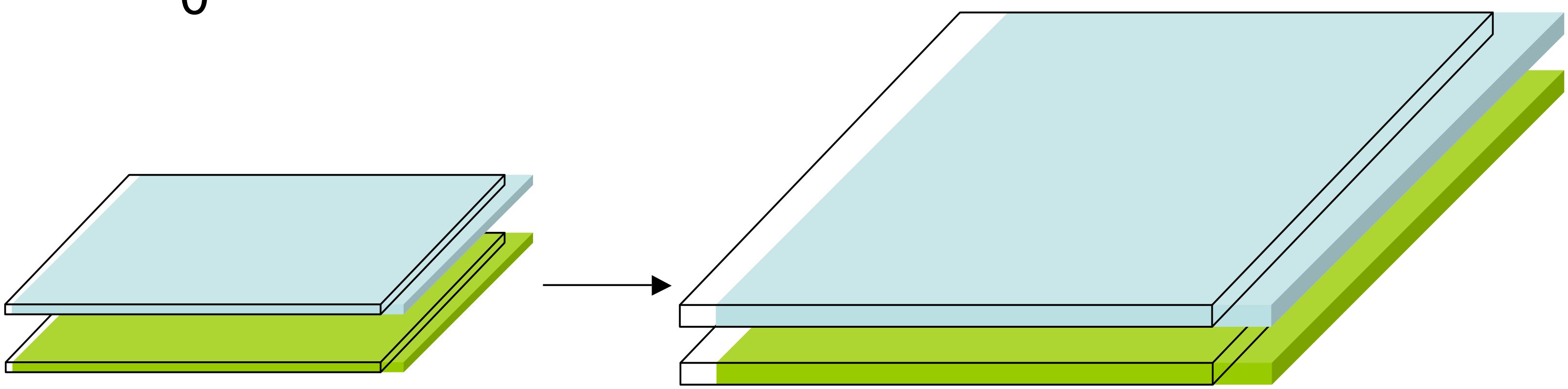
Capacitance depends on geometry:

$$\mathbf{C = \varepsilon_0 A / d}$$

Double the area…

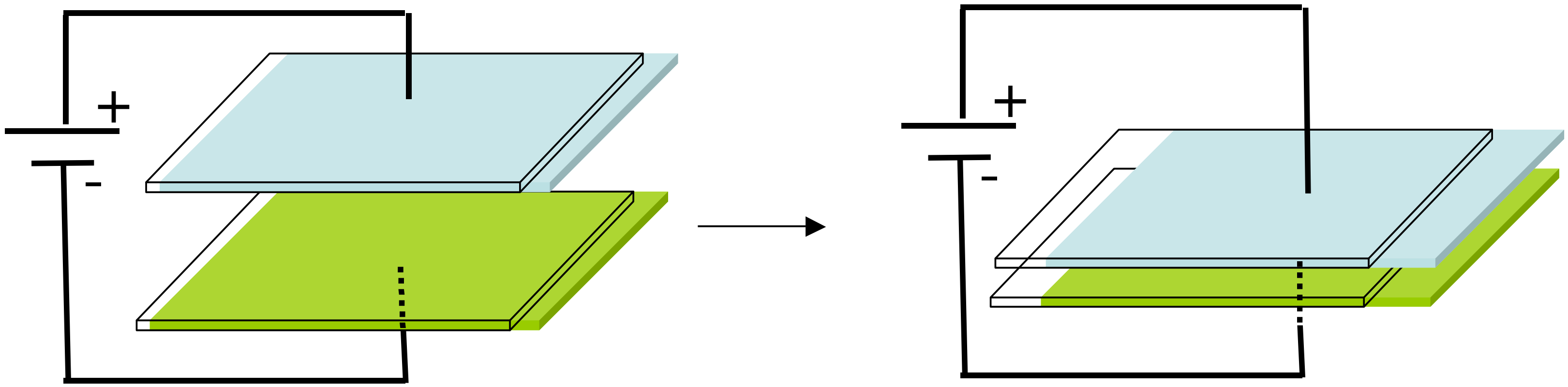
$A \rightarrow 2A$:

$C = \varepsilon_0 A/d$



$C \rightarrow 2C$

If plates are HELD at a fixed potential difference ΔV which does not change as you decrease d:

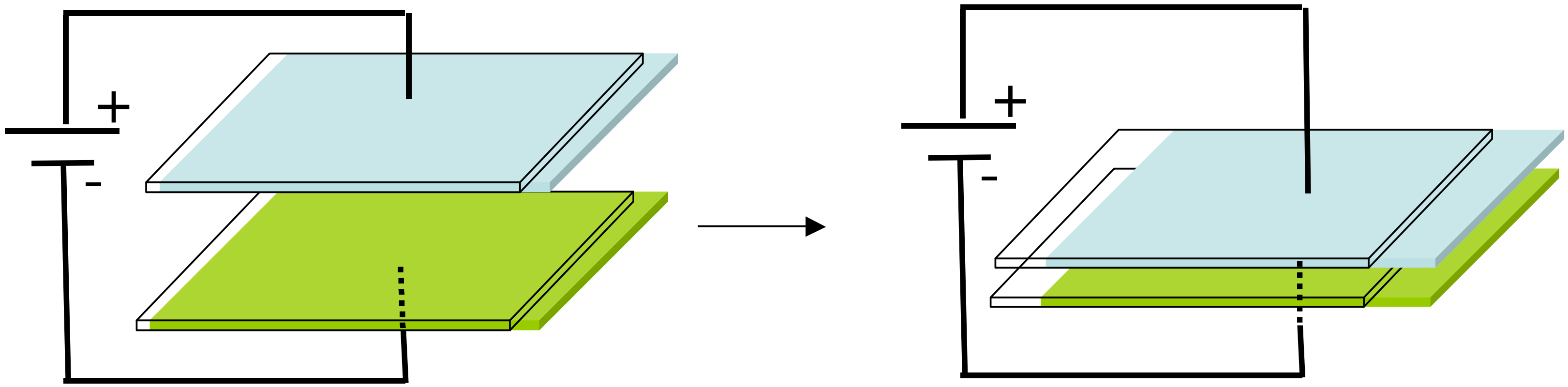


$\Delta V \rightarrow \Delta V$ (held constant)

$d \rightarrow d/2$

What happens to C & E?

If plates are HELD at a fixed potential difference ΔV which does not change as you decrease d:



$\Delta V \rightarrow \Delta V$ (held constant)

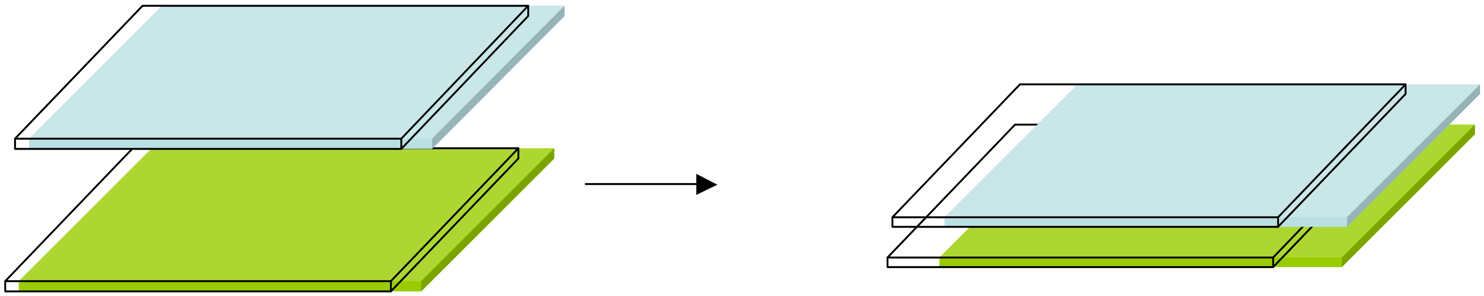
$d \rightarrow d/2$

$E = \Delta V/d$ so $E \rightarrow 2E$

$E = \sigma/\varepsilon_0 = (Q/A)/\varepsilon_0$ so $Q \rightarrow 2Q$

$C = Q/\Delta V$ so $C \rightarrow 2C$

If plates are charged via a battery, then disconnected from it, what happens when d is then halved?



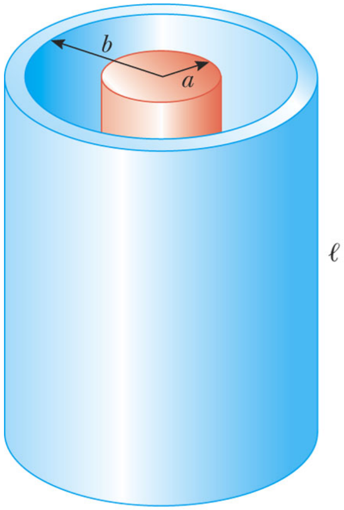
$d \rightarrow d/2$

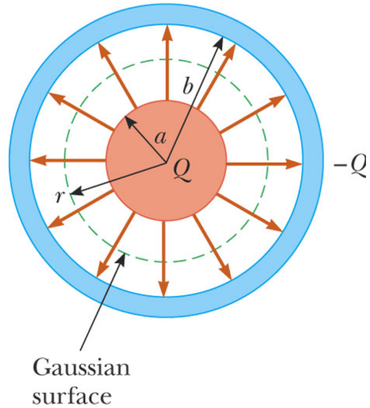
$Q \rightarrow Q$ (isolated system)

$E = \sigma/\varepsilon_0 = (Q/A)/\varepsilon_0$ so $E \rightarrow E$

$\Delta V = Ed$ so $\Delta V \rightarrow \Delta V/2$

$C = Q/\Delta V = \varepsilon_0 A/d$ so $C \rightarrow 2C$





Cylindrical Capacitors

$$\Delta V = V_b - V_a = -\int_a^b E_r dr = -2k_e\lambda \int_a^b \frac{1}{r} dr = -2k_e\lambda \ln(\frac{b}{a})$$

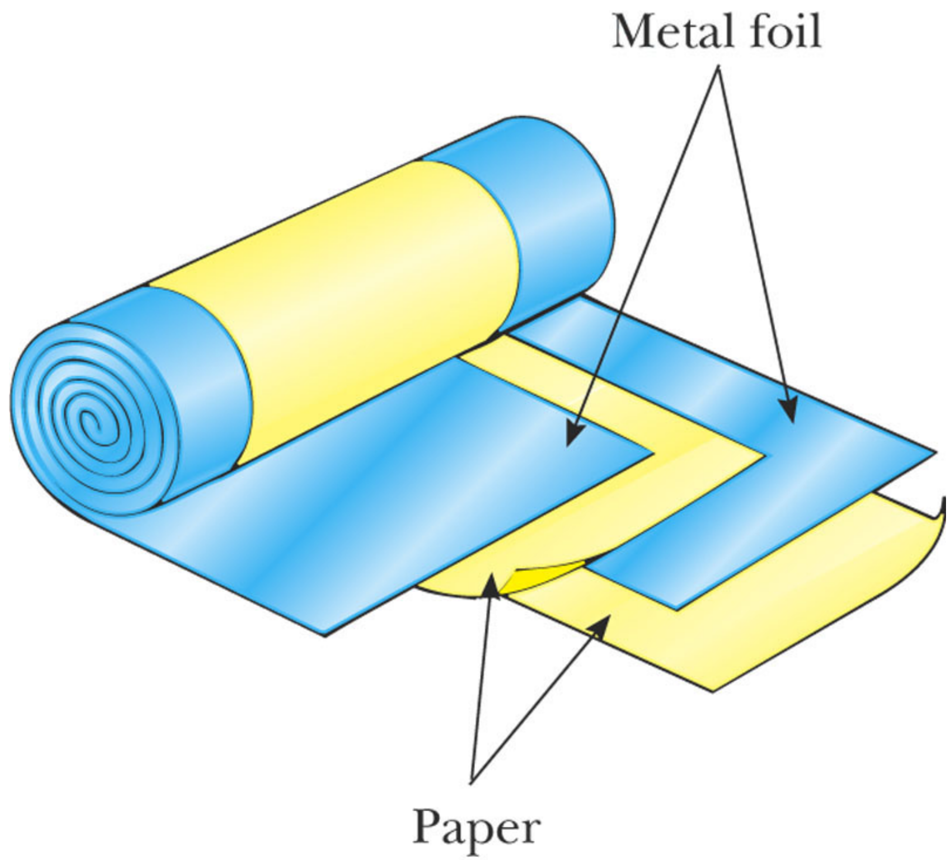
Recall $\lambda = Q/\ell$

$$C = \frac{Q}{\Delta V} = \frac{Q}{\frac{2k_e Q}{\ell} ln(\frac{b}{a})} = \frac{\ell}{2k_e ln(\frac{b}{a})}$$

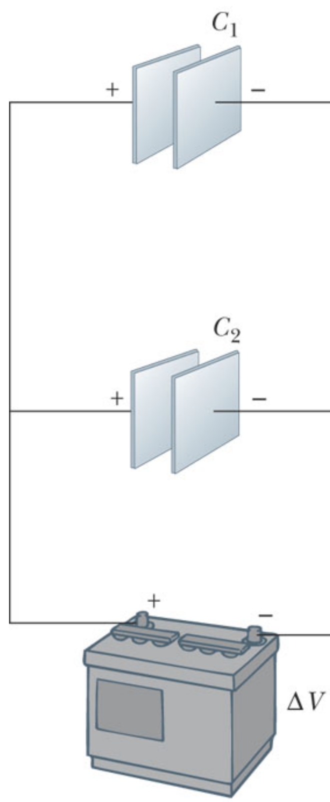
Define capacitance per unit length $C/\ell = \frac{1}{2k_e ln(b/a)}$

Capacitors with insulators (for small d)

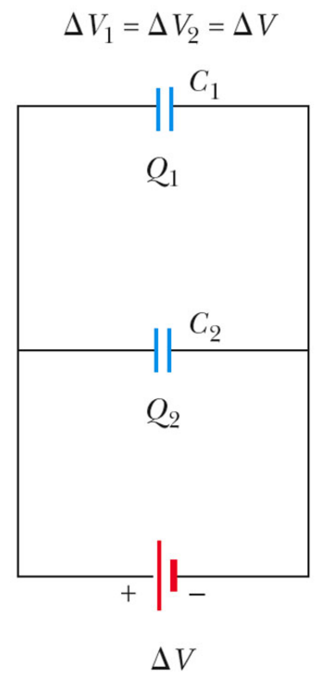
With insulating material filling the gap, charges cannot travel from one plate to the other, but E-fields can permeate.



Circuit diagrams

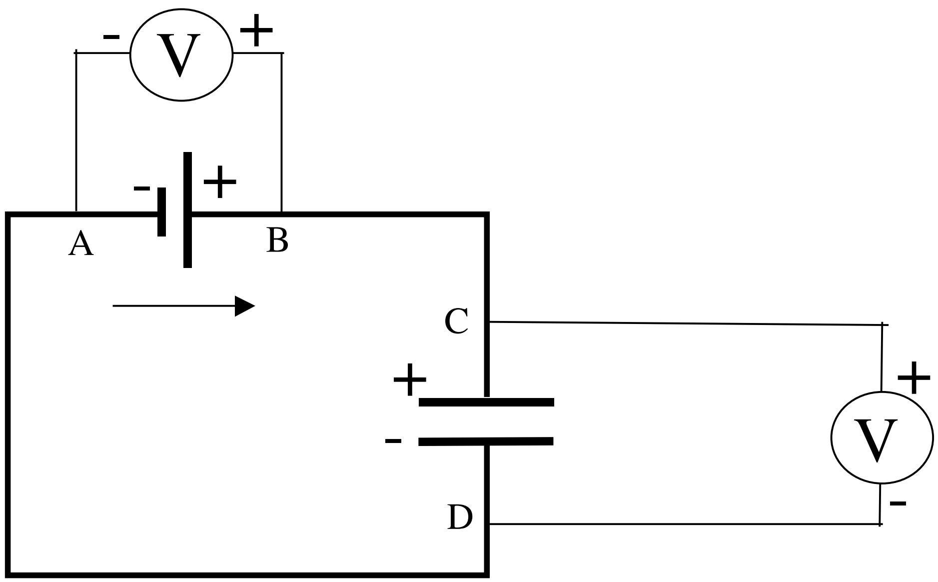


(a)



Voltmeter

Measures ΔV between two points in a circuit



From A to B: Potential increases

From C to D: Potential decreases