Questions

The force responsible for keeping me from falling through the floor is electromagnetic force. Diving board. Done!

Friction is also electromagnetic force. Coefficient of kinetic and static friction. Done!

Is gravitational force really small even though G is small? Done!

Do fundamental particles have color? Done!

Why do objects have color? Is this an intrinsic property of the object? Done!

If neutrinos can pass through a slab of lead one light year thick, how can we detect them? Done!

How many terms do we need to calculate the most complicated integral numerically? Done!

Lightening rod. Done!

Last time

- Electric potential for a line charge
- Electric field from electric potential for a line charge
- Class activity #6

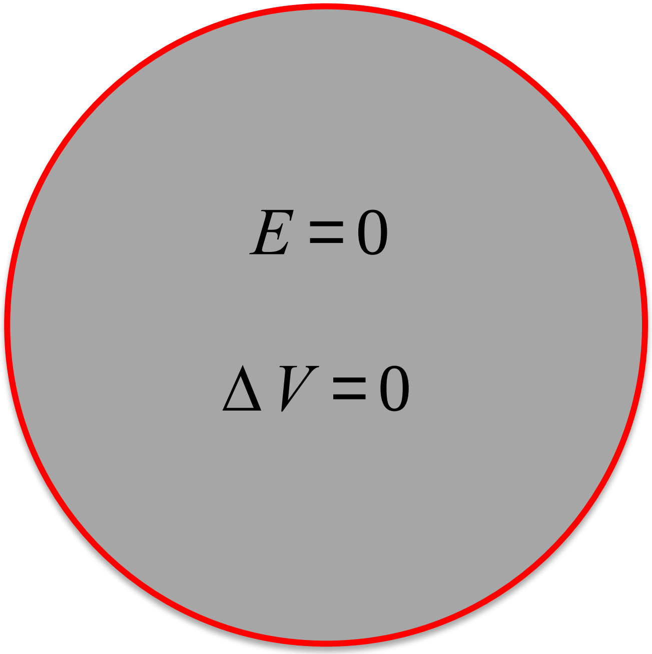
This time

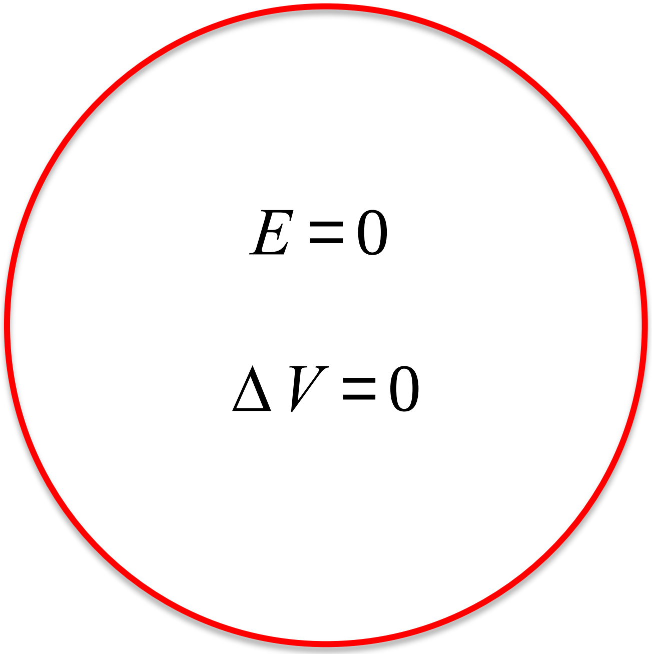
- Insulating spherical shell and a solid spherical conductor
- Potential between two parallel charged plates

Charged insulating shell and a solid conductor with the same charge density and size

$$\left|\vec{E}\right| = \begin{cases} \dfrac{1}{4\pi\varepsilon_0}\dfrac{|q|}{r^2} & r \geq R \\ 0 & r < R \end{cases}$$

$$V = \begin{cases} \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r} & r \geq R \\ \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{R} & r \leq R \end{cases}$$

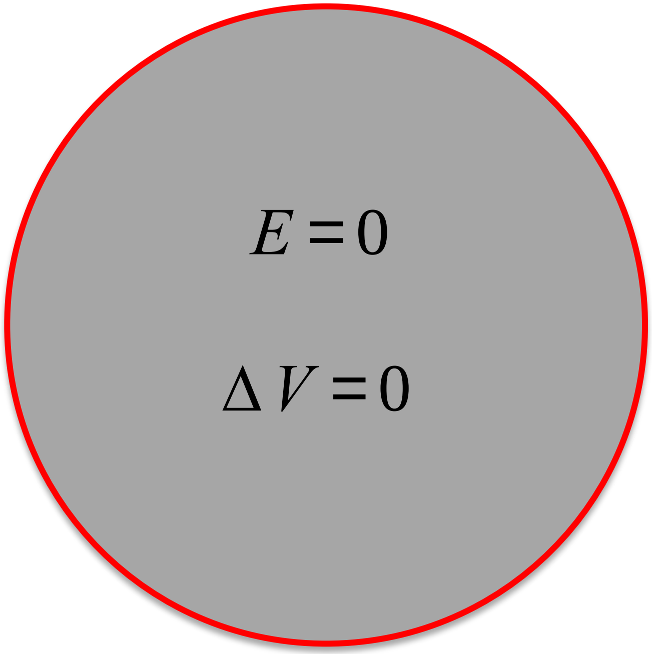


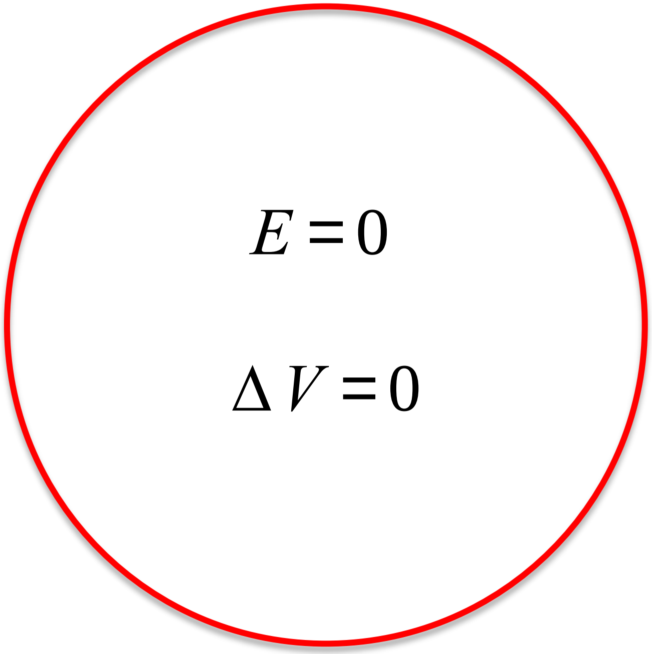


Model of a charged insulating shell

Solid conductor with excess charge +Q evenly distributed on its surface

Hollow insulating shell with charge +Q uniformly distributed on its surface

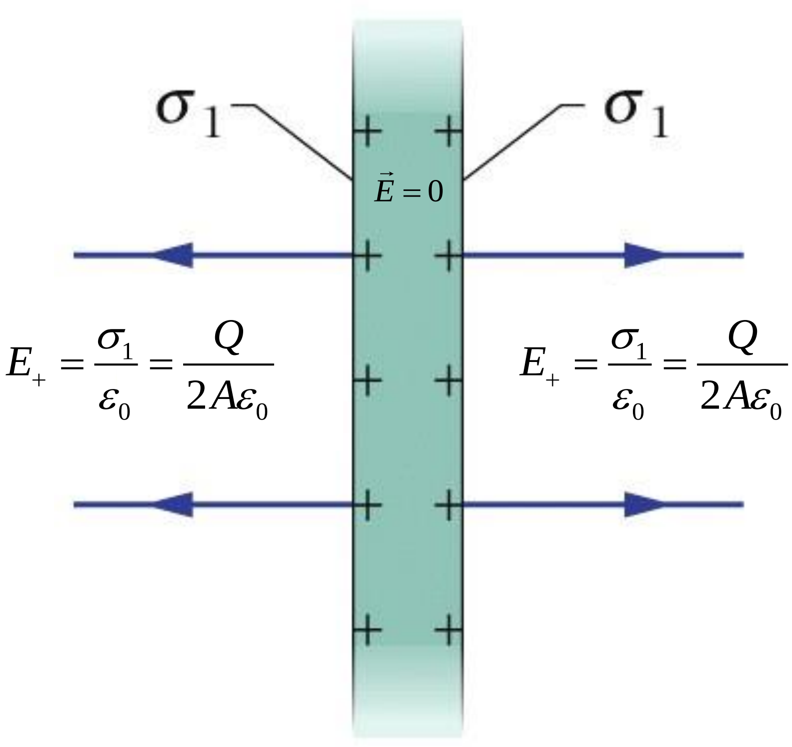




Both objects have the exact same distribution of charges
E and V should be the same for both!

Large conducting plate with a total charge +Q

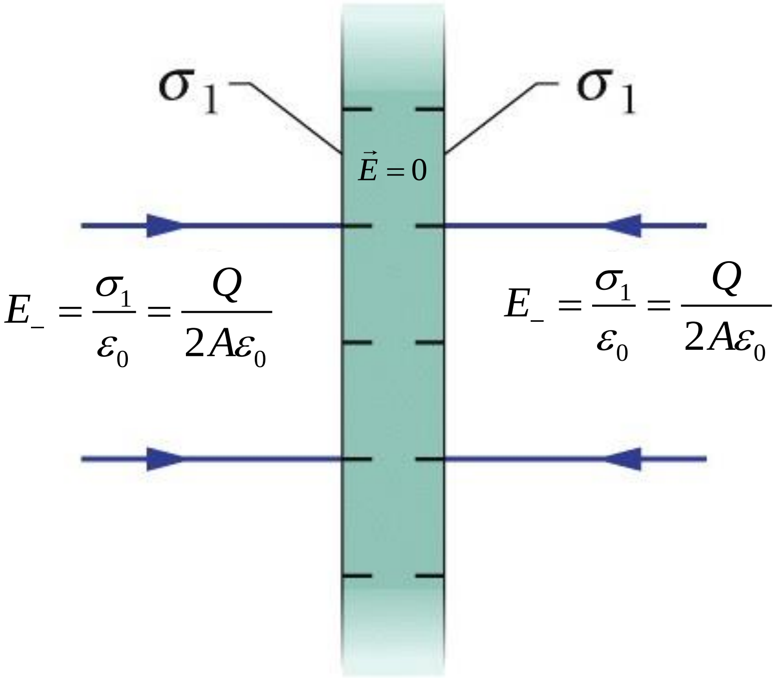
$$\sigma_1 = \frac{Q/2}{A}$$



(a)

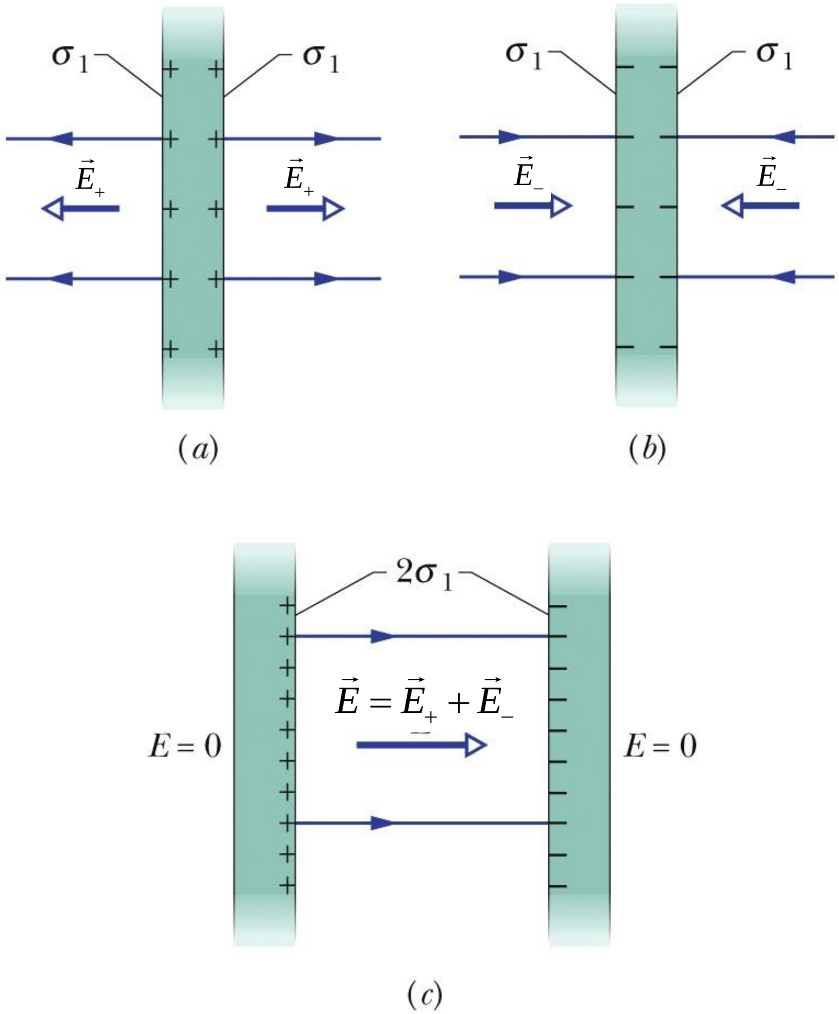
Large conducting plate with a total charge -Q

$$\sigma_1 = \frac{Q/2}{A}$$



(b)

Putting the two plates together

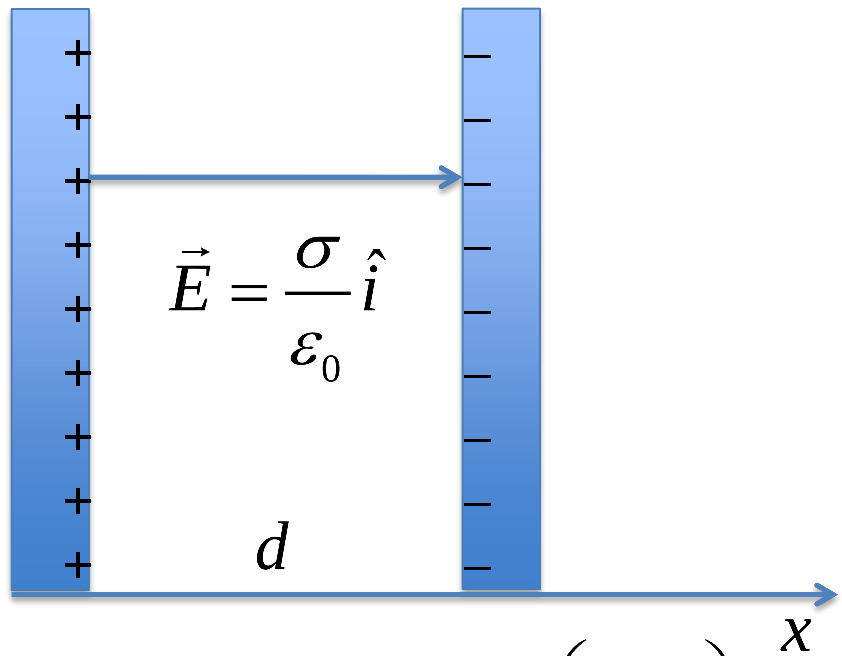


$$\sigma = 2\sigma_1 = \frac{Q}{A}$$

$$\vec{E} = \vec{E}_+ + \vec{E}_- = \frac{Q}{2A\varepsilon_0} + \frac{Q}{2A\varepsilon_0} = \frac{Q}{A\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$ From positive plate to negative plate

Application: Makes a parallel plate capacitor!

Parallel plate capacitor



$$\sigma = \frac{Q}{A}$$

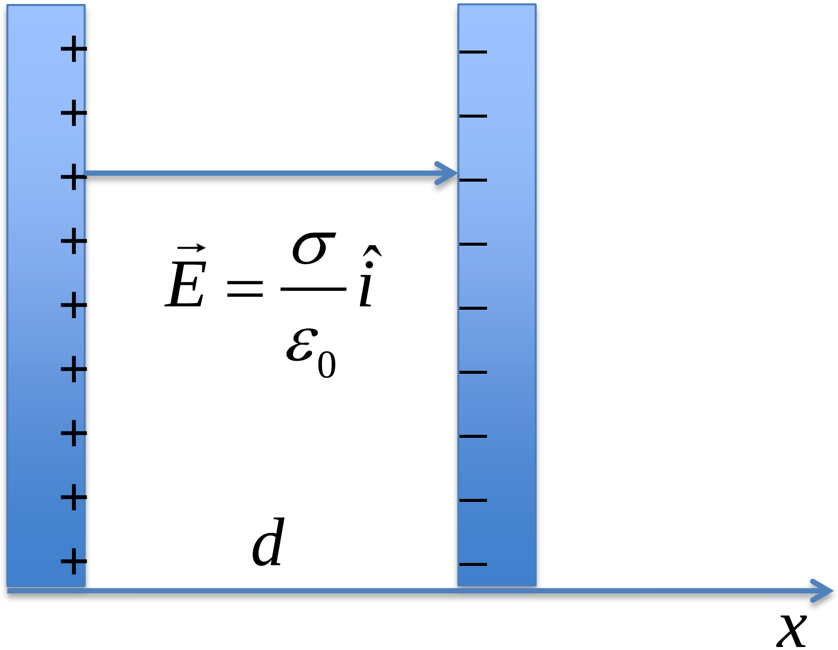
$$V_f - V_i = -\int_i^f \vec{E} \bullet d\vec{l} \qquad V_- - V_+ = -\int_i^f \left(\frac{\sigma}{\varepsilon_0}\hat{i}\right) \bullet d\vec{l}$$

Choose the integration path to be a straight line from the positive plate to the negative plate.

$$d\vec{l} = dx\hat{i}$$

$$V_- - V_+ = -\int_0^d \left(\frac{\sigma}{\varepsilon_0}\hat{i}\right) \bullet \left(dx\hat{i}\right) = -\int_0^d \left(\frac{\sigma}{\varepsilon_0}\right) dx = -\frac{\sigma}{\varepsilon_0} d$$

Parallel plate capacitor

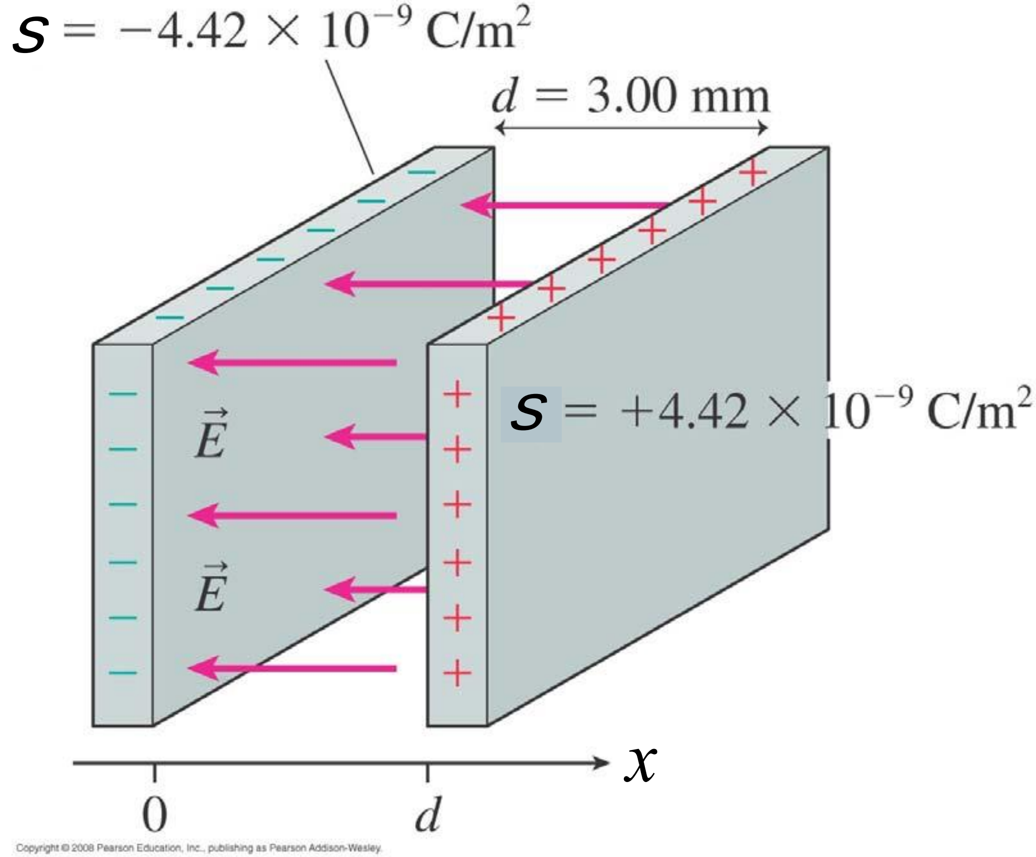


$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{i}$$

$$\sigma = \frac{Q}{A}$$

$$V_+ - V_- = \Delta V = \frac{\sigma}{\varepsilon_0}d = \frac{Q}{A\varepsilon_0}d$$

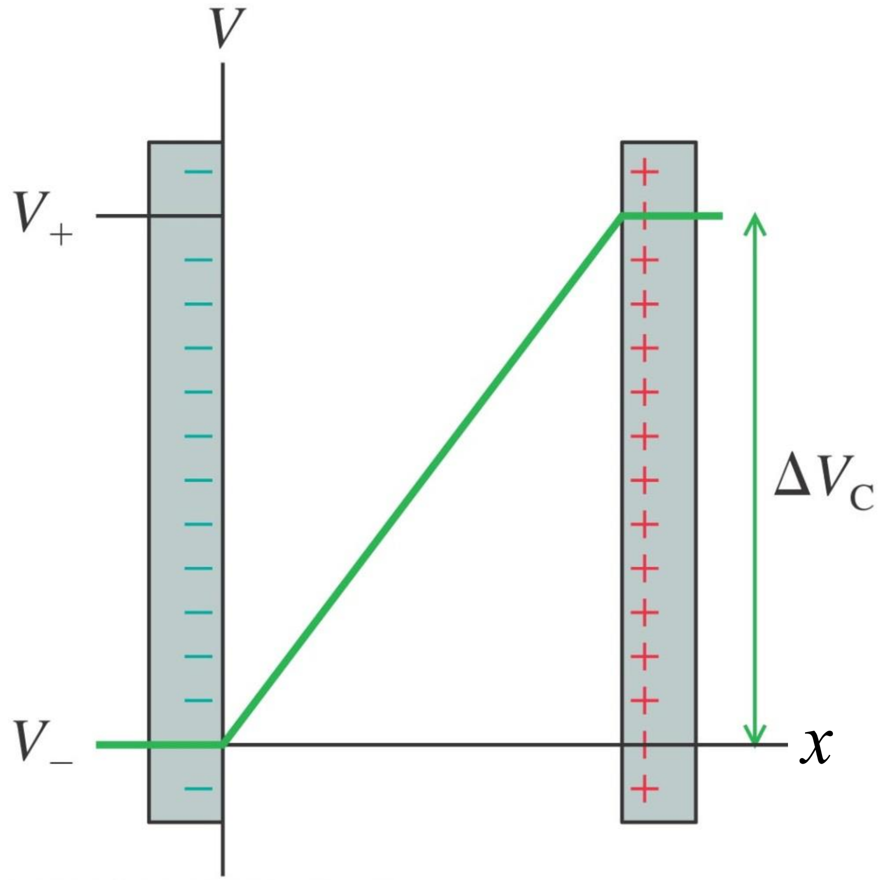
The source charges on the capacitor plates create a uniform electric field between the plates of

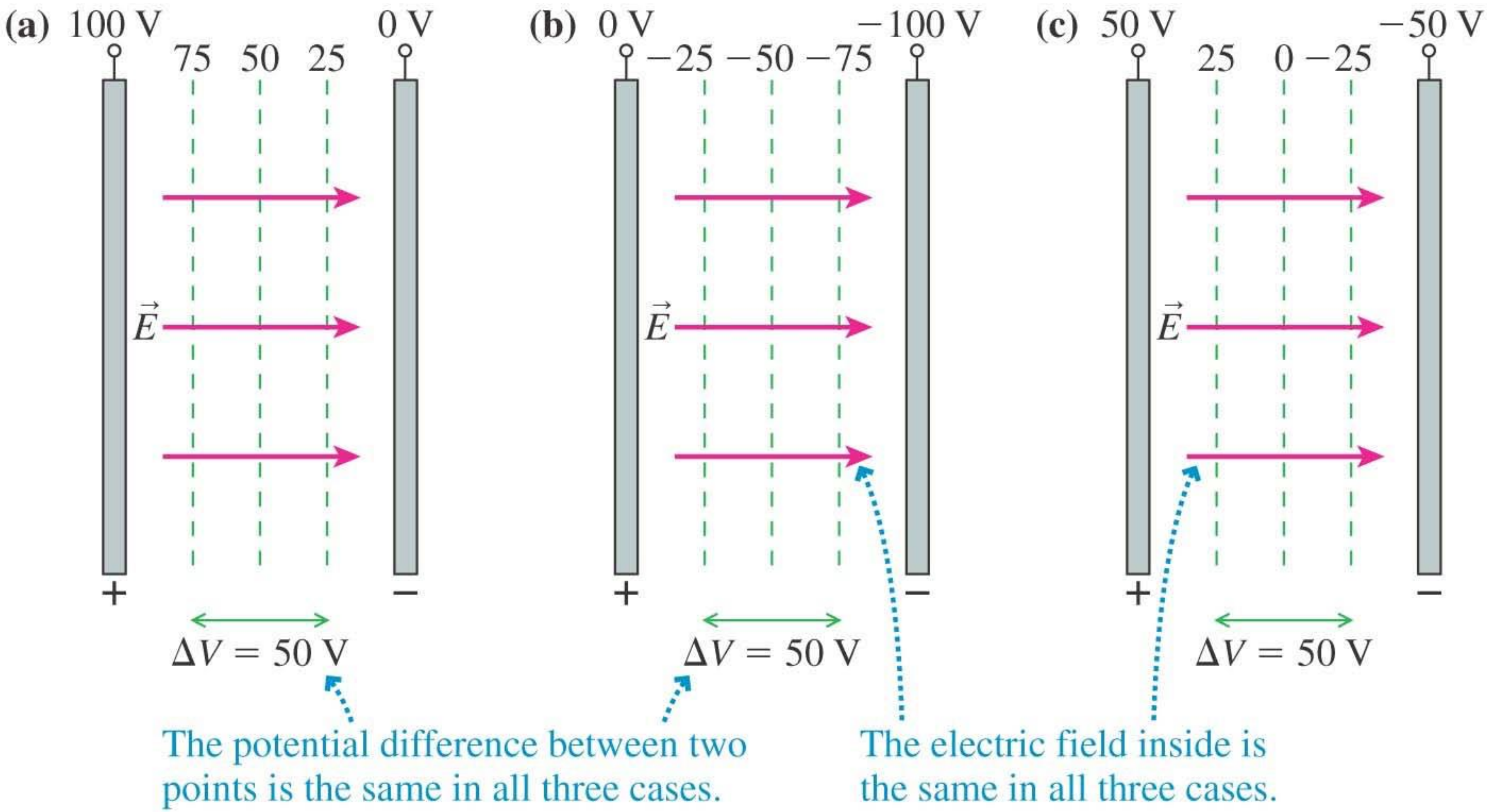


$$\vec{E} = \frac{\sigma}{\varepsilon_0} \text{ from positive to negative}$$

$$\Delta V_C = \frac{\sigma}{\varepsilon_0} d = \left(\frac{d}{A\varepsilon_0} \right) Q$$

The electric potential inside a charged capacitor increases linearly from the negative to the positive plate.





We can define V = 0 anywhere we want. Our choice of V = 0 does not affect any potential differences or the electric field.