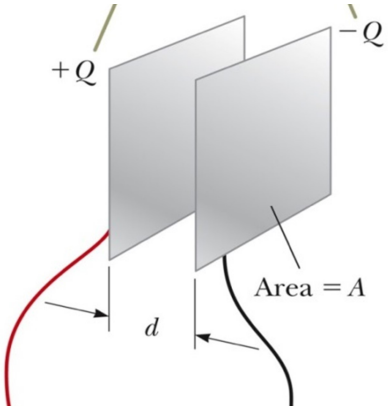
Parallel Plate Capacitor

Tuesday, 2 February, 2021 07:39

Two parallel, metallic plates of equal area A are separated by a distance d. One plate carries a charge $+Q$, and the other carries a charge $-Q$. The surface charge density on each plate is $\sigma = Q/A$. Find the capacitance of this device.



Answer: The capacitance is

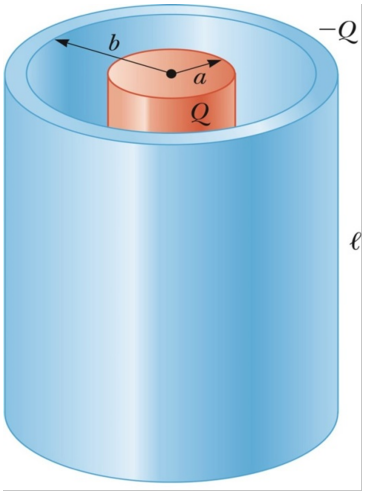
$$C = \frac{A\epsilon_o}{d}$$

The capacitance is proportional to the area of its plates and inversely proportional to the distance between the plates.

The Cylindrical Capacitor

Tuesday, 2 February, 2021 07:25

A solid cylindrical conductor of radius a and charge $+Q$ is coaxial with a cylindrical shell of negligible thickness, radius $b > a$, and charge $-Q$. Find the capacitance of this cylindrical capacitor if its length is ℓ.



Answer: The capacitance is

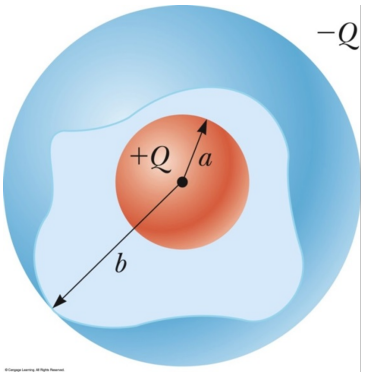
$$C = \frac{Q}{\Delta V} = \frac{l}{2k_e ln(b/a)}$$

The capacitance depends on the radii (a) and (b) and is proportional to the length of the cylinders

The Spherical Capacitor

Tuesday, 2 February, 2021 07:30

A spherical capacitor consists of a spherical conducting shell of radius (b) and charge $-Q$ concentric with a smaller conducting sphere of radius (a) and charge $+Q$. Find the capacitance of this device.



Answer: The capacitance is

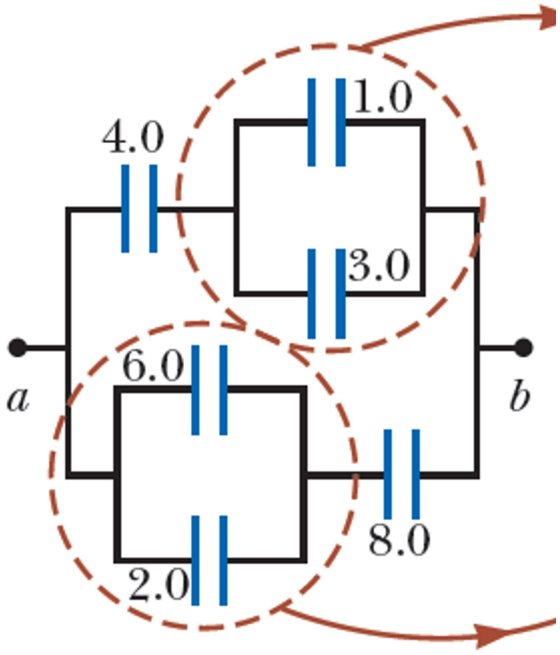
$$C = \frac{Q}{\Delta V} = \frac{ab}{k_e(b-a)}$$

The capacitance depends on the radii (a) and (b) .

Equivalent Capacitance

Friday, 29 January, 2021 21:00

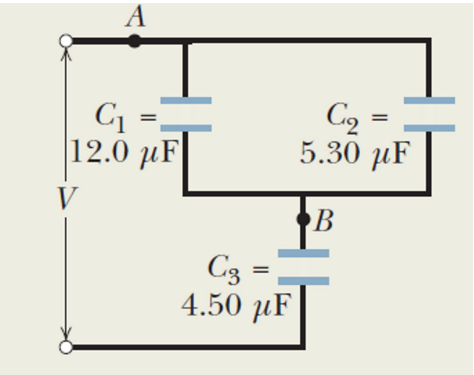
Find the equivalent capacitance between (a) and (b) for the combination of capacitors shown in the figure. All capacitances are in microfarads.



Capacitors in parallel and in series

Friday, 29 January, 2021 21:01

- Find the equivalent capacitance for the combination of capacitances shown in the figure, across which potential difference (V) is applied. Assume $C_1 = 12\,\mu F$, $C_2 = 5.3\,\mu F$ and $C_3 = 4.5\,\mu F$.



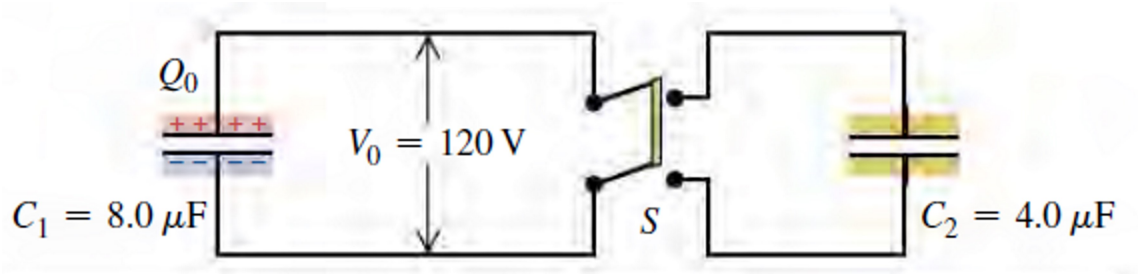
- The potential difference applied to the input terminals is $V = 12.5\,V$. What is the charge on C_1 ?and
- The energy stored in C_1 ?

Transferring Charge and Energy between Capacitors

Friday, 29 January, 2021 21:02

We connect a capacitor $C_1 = 8\,\mu F$ to a power supply, charge it to a potential difference $V_\circ = 120\,V$, and disconnect the power supply as shown in the figure. Switch S is open.

- What is the charge $Q_\circ$ on C_1?
- What is the energy stored in C_1?
- Capacitor $C_2 = 4\,\mu F$ is initially uncharged. We close switch S. After charge no longer flows, what is the potential difference across each capacitor, and
- What is the charge on each capacitor?
- What is the final energy of the system?

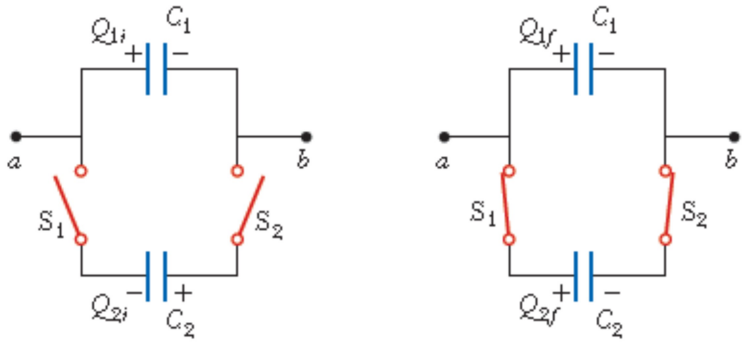


Rewiring Two Charged Capacitors

Tuesday, 2 February, 2021 16:42

Two capacitors C_1 and C_2 (where $C_1 > C_2$) are charged to the same initial potential difference ΔV_i . The charged capacitors are removed from the battery, and their plates are connected with opposite polarity. The switches S_1 and S_2 are then closed.

- Find the final potential difference ΔV_f between a and b after the switches are closed.
- Find the total energy stored in the capacitors before and after the switches are closed and determine the ratio of the final energy to the initial energy.



Energy Stored Before and After

Tuesday, 2 February, 2021 16:52

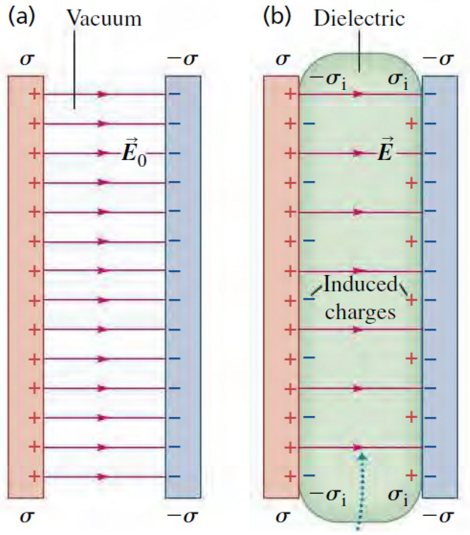
A parallel-plate capacitor is charged with a battery to a charge Q_o. The battery is then removed, and a slab of material that has a dielectric constant κ is inserted between the plates. Identify the system as the capacitor and the dielectric. Find the energy stored in the system before and after the dielectric is inserted.

A capacitor with and without a dielectric

Friday, 29 January, 2021 21:02

Suppose the parallel plates shown in the figure each have an area of $2000\,cm^2$ and are $1\,cm$ apart. We connect the capacitor to a power supply, charge it to a potential difference $V_\circ = 3\,kV$, and disconnect the power supply. We then insert a sheet of insulating plastic material between the plates, completely filling the space between them. We find that the potential difference decreases to $1\,kV$ while the charge on each capacitor plate remains constant. Find:

- the original capacitance $C_\circ$;
- the magnitude of charge Q on each plate;
- the capacitance C after the dielectric is inserted;
- the dielectric constant κ of the dielectric;
- the permittivity ε of the dielectric;
- the magnitude of the induced charge Q_i on each face of the dielectric;
- the original electric field $E_\circ$ between the plates; and
- the electric field E after the dielectric is inserted.



The H_2O Molecule

Tuesday, 2 February, 2021 16:55

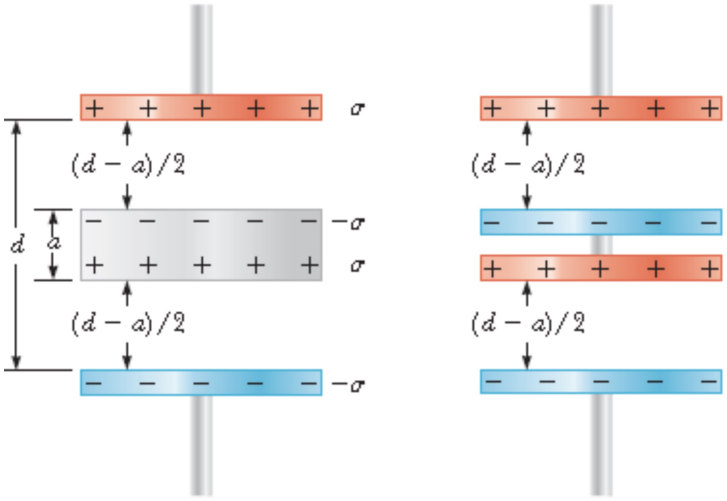
The water (H_2O) molecule has an electric dipole moment of $6.3 \times 10^{-30}\ C.m$. A sample contains 10^{21} water molecules, with the dipole moments all oriented in the direction of an electric field of magnitude $2.5 \times 10^{5}\ N/C$. How much work is required to rotate the dipoles from this orientation $(\theta = 0^o)$ to one in which all the moments are perpendicular to the field $(\theta = 90^o)$?

Effect of a Metallic Slab

Tuesday, 2 February, 2021 17:02

A parallel-plate capacitor has a plate separation d and plate area A. An uncharged metallic slab of thickness a is inserted midway between the plates.

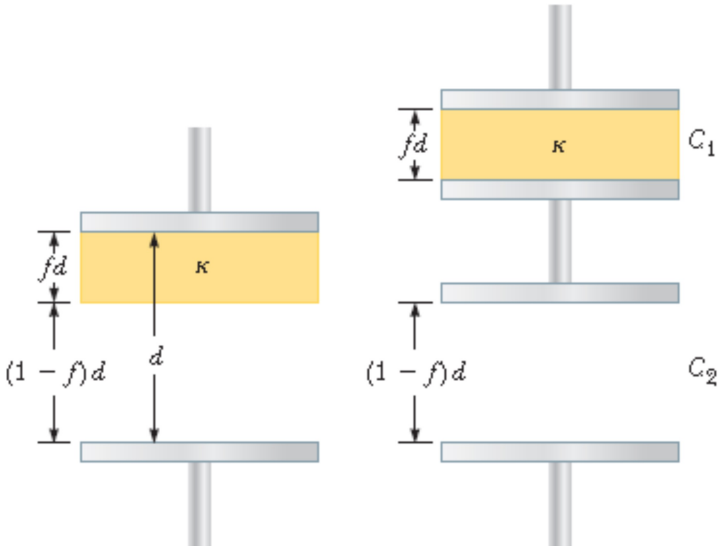
- Find the capacitance of the device.
- Show that the capacitance of the original capacitor is unaffected by the insertion of the metallic slab if the slab is infinitesimally thin.



A Partially Filled Capacitor

Tuesday, 2 February, 2021 17:05

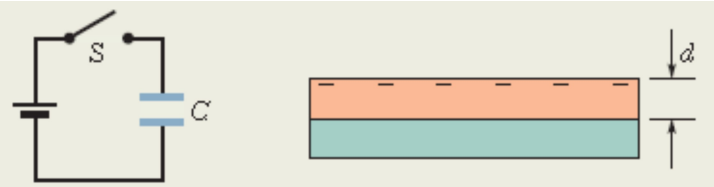
A parallel-plate capacitor with a plate separation d has a capacitance C_o in the absence of a dielectric. What is the capacitance when a slab of dielectric material of dielectric constant κ and thickness fd is inserted between the plates, where f is a fraction between 0 and 1?



Charging the plates in a parallel-plate capacitor

Tuesday, 2 February, 2021 18:09

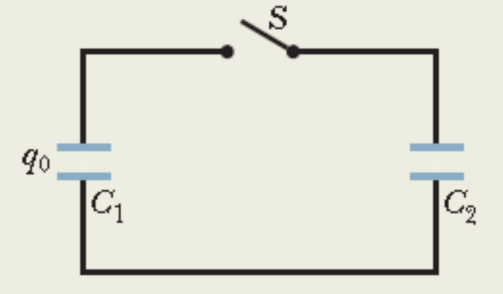
In the figure shown, switch S is closed to connect the uncharged capacitor of capacitance $C = 0.25\,\mu F$ to the battery of potential difference $V = 12\,V$.The lower capacitor plate has thickness $L = 0.50\,cm$ and face area $A = 2.0 \times 10^{-4}\,m^2$, and it consists of copper, in which the density of conduction electrons is $n = 8.49 \times 10^{28}\ electrons/m^3$. From what depth d within the plate must electrons move to the plate face as the capacitor becomes charged?



One capacitor charging up another capacitor

Tuesday, 2 February, 2021 18:17

Capacitor 1, with $C_1 = 3.55\,\mu F$, is charged to a potential difference $V_o = 6.30\,V$, using a $6.30\,V$ battery.The battery is then removed, and the capacitor is connected to an uncharged capacitor 2, with $C_2 = 8.95\,\mu F$.When switch S is closed, charge flows between the capacitors. Find the charge on each capacitor when equilibrium is reached.



Potential energy and energy density of an electric field

Tuesday, 2 February, 2021 18:25

An isolated conducting sphere whose radius R is $6.85\,cm$ has a charge $q = 1.25\,nC$.

- How much potential energy is stored in the electric field of this charged conductor?
- What is the energy density at the surface of the sphere?

Work and energy when a dielectric is inserted into a capacitor

Tuesday, 2 February, 2021 19:59

A parallel-plate capacitor whose capacitance $C = 13.5\,pF$ is charged by a battery to a potential difference $V = 12.5\,V$ between its plates. The charging battery is now disconnected, and a porcelain slab ($\kappa = 6.50$) is slipped between the plates.

- What is the potential energy of the capacitor before the slab is inserted?
- What is the potential energy of the capacitor–slab device after the slab is inserted?

Dielectric partially filling the gap in a capacitor

Tuesday, 2 February, 2021 20:03

A parallel-plate capacitor of plate area A and plate separation d. A potential difference V_o is applied between the plates by connecting a battery between them. The battery is then disconnected, and a dielectric slab of thickness b and dielectric constant κ is placed between the plates as shown. Assume $A = 115\ cm^2$, $d = 1.24\ cm$, $V_o = 85.5\ V$, $b = 0.780\ cm$, and $\kappa = 2.61$.

- What is the capacitance C_o before the dielectric slab is inserted?
- What free charge appears on the plates?
- What is the electric field E_o in the gaps between the plates and the dielectric slab?
- What is the electric field E_1 in the dielectric slab?
- What is the potential difference V between the plates after the slab has been introduced?
- What is the capacitance with the slab in place?