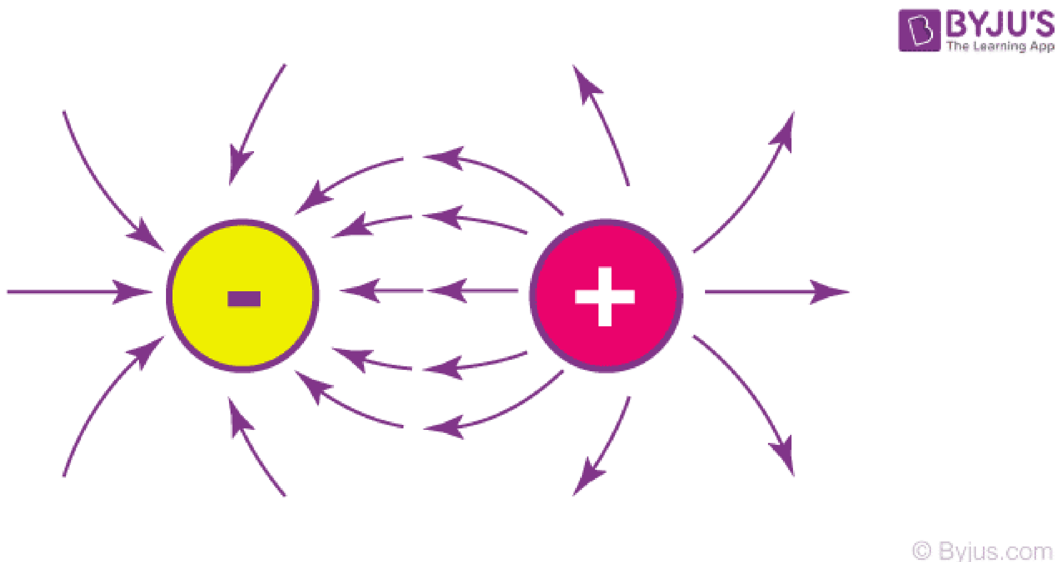
Electrostatics

What is electrostatics?

Electrostatics is a branch of physics that deals with the phenomena and properties of stationary or slow-moving electric charges. Electrostatic phenomena arise from the forces that electric charges exert on each other and are described by Coulomb’s law. Even though electrostatically induced forces seem to be relatively weak.



Why is it called static?

It is called “static” because the displaced electrons tend to remain stationary after being moved from one insulating material to another.

How does electrostatics work?

Electrostatic phenomena arise from the forces that electric charges exert on each other and are described by Coulomb’s law. Even though electrostatically induced forces seem to be relatively weak.

Why is electrostatic force conservative?

The electrostatic force is conservative in nature because the work done on the charge is independent of the path taken.

What are the examples of electrostatics?

The attraction of the plastic wrap to your hand after you remove it from a package and the attraction of paper to a charged scale.

Why is electrostatic force a central force?

The electrostatic force is called a central force because it acts along the line joining two charges.

What are the benefits of static electricity?

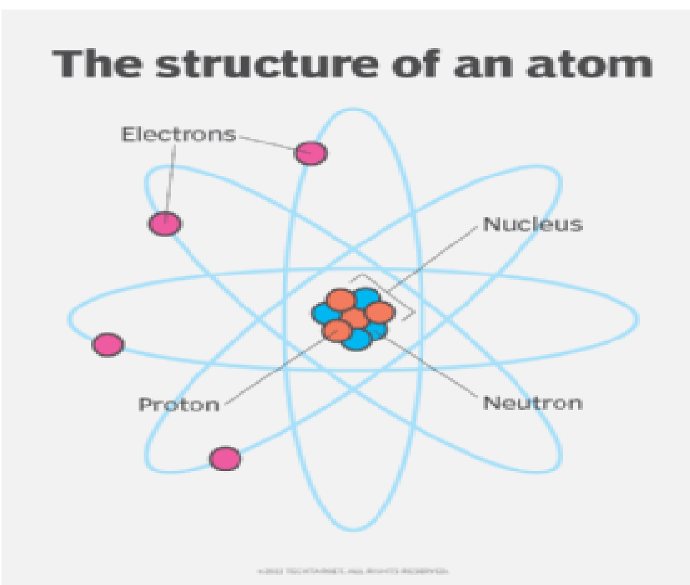
Static electricity has several uses, also called applications, in the real world. One main use is in printers and photocopiers where static electric charges attract the ink, or toner, to the paper. Other uses include paint sprayers, air filters, and dust removal.

What is Coulomb's law in electrostatics?

According to Coulomb, the electric force for charges at rest has the following properties: Like charges repel each other; unlike charges attract. Thus, two negative charges repel one another, while a positive charge attracts a negative charge. The attraction or repulsion acts along the line between the two charges.

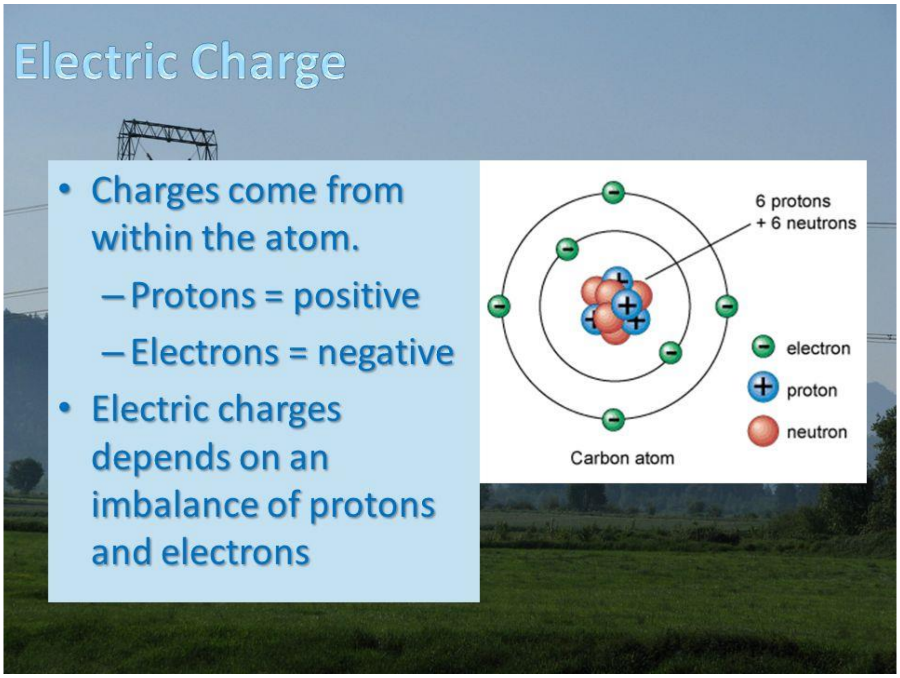
What is an electrostatic field?

When two objects in each other's vicinity have different electrical charges, an electrostatic field exists between them. An electrostatic field also forms around any single object that is electrically charged with respect to its environment.



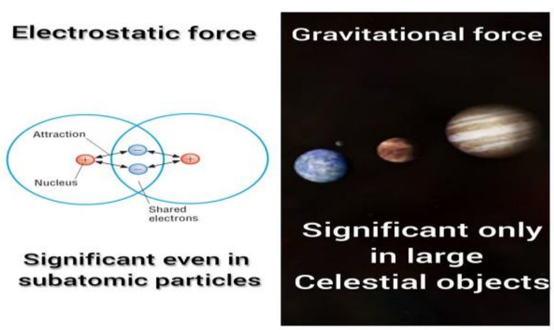
Charge and Matter

In an atom of matter, an electrical charge occurs whenever the number of protons in the nucleus differs from the number of electrons surrounding that nucleus. If there are more electrons than protons, the atom has a negative charge. If there are fewer electrons than protons, the atom has a positive charge.



What is the difference between charge and matter?

Charge is the property of matter by virtue of which it shows electric effect. Mass is the property which gives measure of substance of a body. Also, Charge is the property that results in the electrostatic forces. On the other hand, Mass is the property that results in the gravitational forces.



What is the definition of a charge?

Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. Positive and negative electric charges are the two types of charges commonly carried by charge carriers, protons and electrons. Energy is created by the movement of charges.

Why is charge associated with matter?

Charge is the fundamental property of matter that exhibits electrostatic attraction or repulsion in the presence of other matter with charge. Electric charge is a characteristic property of many subatomic particles.

Does charge exist without matter?

The statement that "a charge can exist without mass" is false. This is because none of the fundamental particles that form the Standard Model have charge without mass. The Standard Model describes all energy and matter that makes up the universe, except gravitation. And gravitation does not have charge, it has mass.

What is the difference between charge and matter distribution of nucleus?

They are determined by the structure of the nucleus, and strongly affect the ways the nucleus interacts with other particles. The charge distribution is mainly determined by the arrangement of the protons, and the matter distribution by those of the neutrons and protons combined.

Is all matter made of charged particles?

All matter is composed of divisible particles called atoms. The atoms are composed of tiny charged subatomic particles named electrons, protons, and neutrons.

Do charges have mass?

Electrical charge does not exist without mass, in fact, it might be called a property of mass which in itself is a form of energy, as discovered by Einstein.

Are atoms always charged?

So an atom as a whole is electrically neutral. When one or more electrons is stripped away from an atom, it becomes positively charged. Some atoms can attract additional electrons so they become negatively charged. Atoms which are not electrically neutral are called ions.

What is matter and its types?

Matter is a substance made up of various types of particles that occupies physical space and has inertia. According to the principles of modern physics, the various types of particles each have a specific mass and size. The most familiar examples of material particles are the electron, the proton and the neutron.

Coulomb's Law

According to **Coulomb's law**, the force of attraction or repulsion between two charged bodies is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. It acts along the line joining the two charges considered to be point charges.

Coulomb's Law – Gives the electric force between two point charges.

$$F = k\frac{q_1 q_2}{r^2}$$

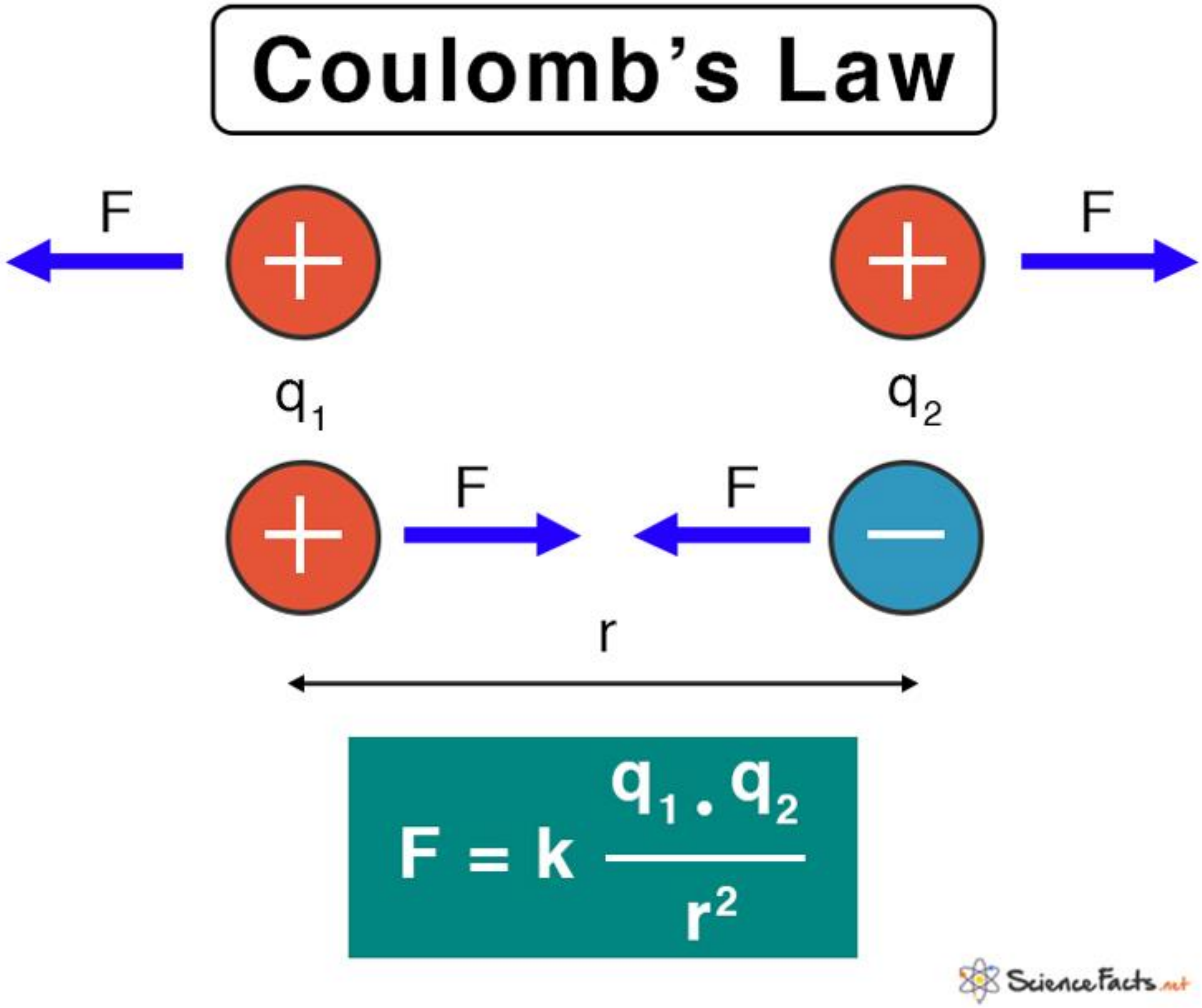
Inverse Square Law

k = Coulomb's Constant = 9.0×10^{9} Nm^2/C^2

q_1 = Point charge -1

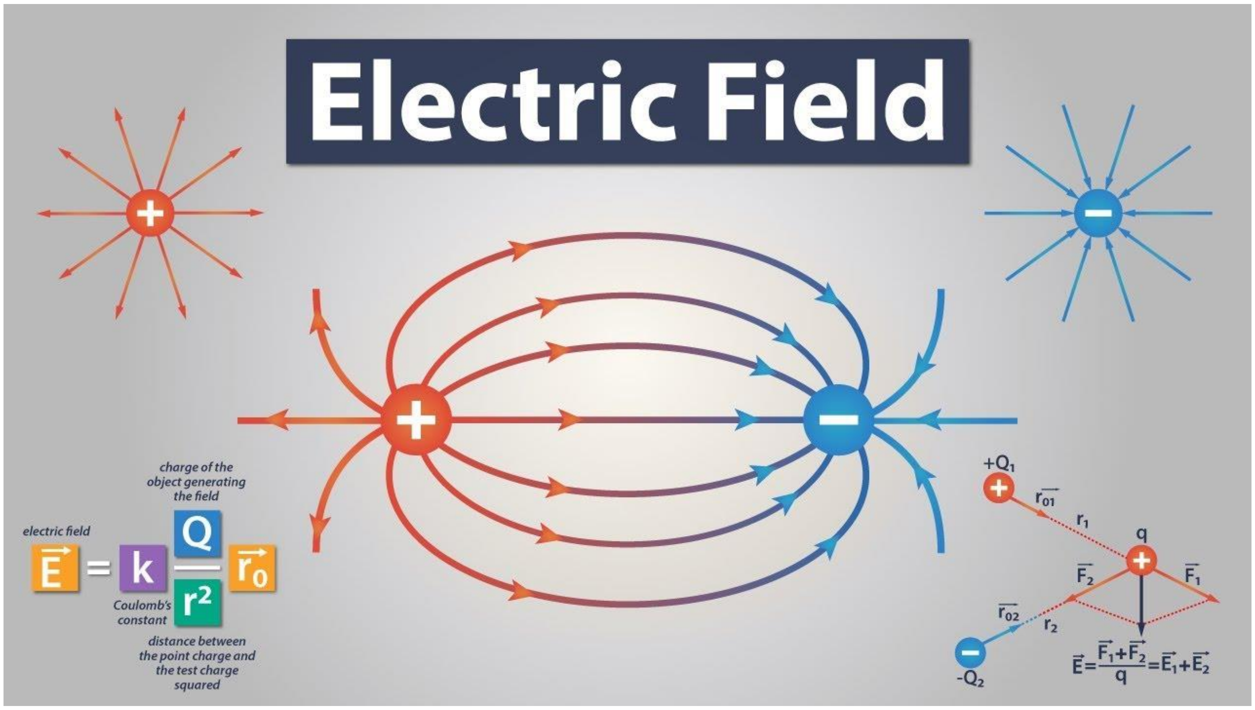
q_2 = Point charge - 2

r = the distance between the two charges



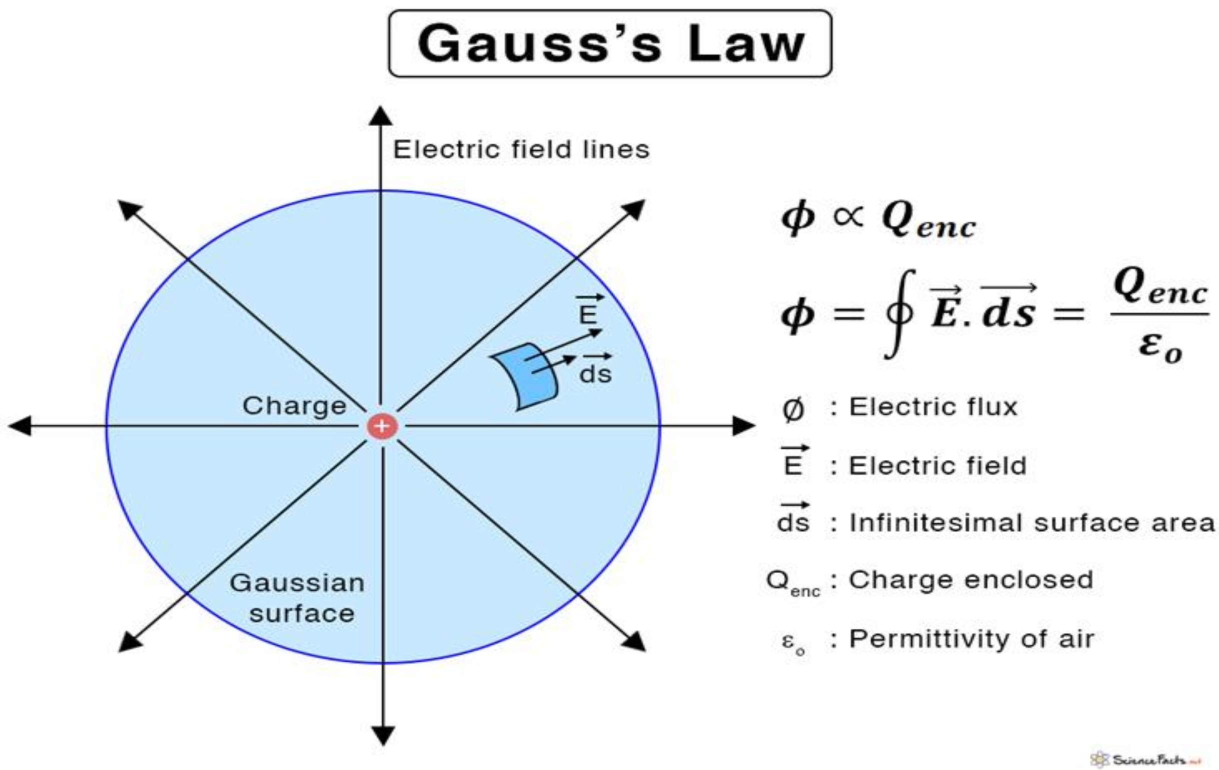
The electric field

An electric field is an invisible force field created by the attraction and repulsion of electrical charges (the cause of electric flow), and is measured in Volts per meter (V/m). The intensity of the electric field decreases with distance from the field source.

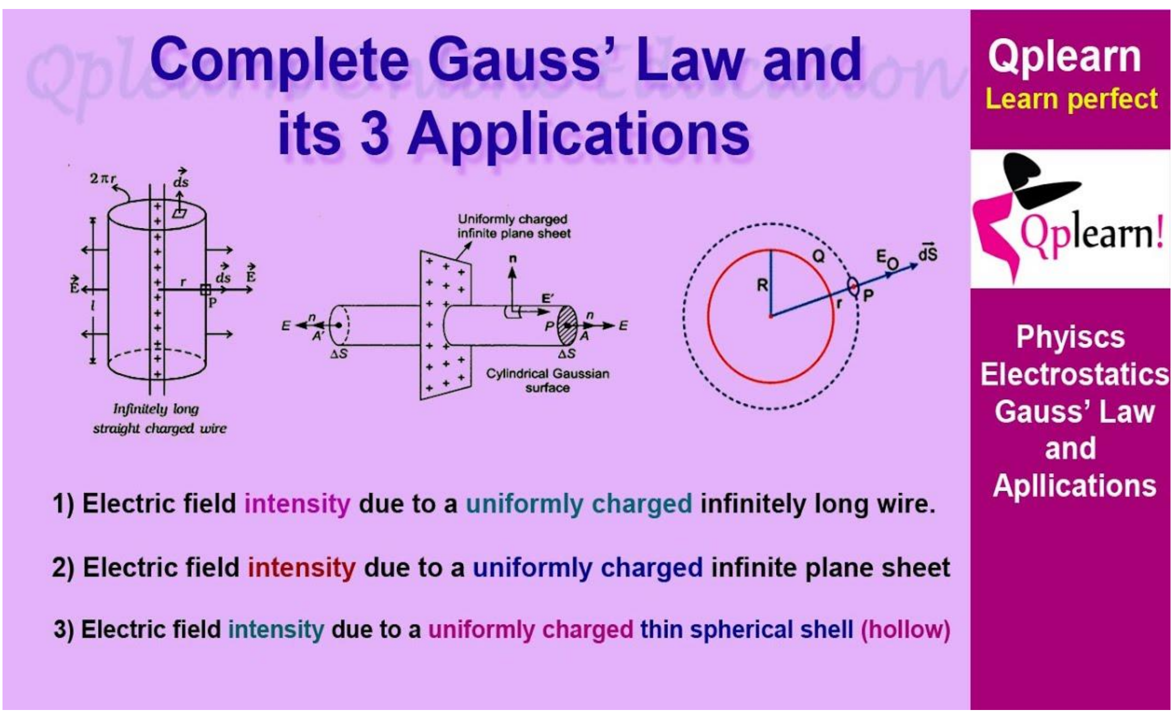


Gauss's Law

The formula for Gauss' Law involves the electric flux, the charge enclosed, and the permittivity of free space constant. The electric flux is equal to the charge enclosed divided by the permittivity of free space constant.



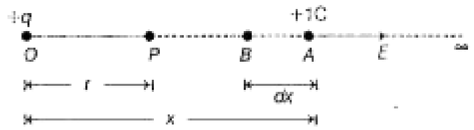
Applications of Gauss's Law: To find out the field due to a uniformly charged Straight wire, a uniformly charged Infinite plate sheet, a uniformly charged thin spherical shell, and a low uniformly charged sphere. Gauss's law helps obtain the electrical field of these closed surfaces.



Derive an expression for the potential at a distance r from a point charge +q**.**

Solution

Potential due to a point charge Let P be the point at a distance r from the origin O at which the electric potential due to charge +q is required



The electric potential at a point P is the amount of work done in carrying a unit positive charge from ∞ to P. As work done is independent of the path, we choose a convenient path along the radial direction from infinity to the point P without acceleration. Let A be an intermediate point on this path, where OA= x. The electrostatic force on unit positive charge at A is $F = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$, (along OA)...(i)
Small work done in moving the charge through a distance dx from A to B, dW=Fdx=Fdxcos180∘=−Fdx[∵cos180∘=−1]dW=−Fdx ....(ii)

Total work done in moving unit positive charge from ∞ to the point P is

$$W = \int_{\infty}^{r} -Fdx = \int_{\infty}^{r} -\frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}dx = -\frac{q}{4\pi\varepsilon_0}\int_{\infty}^{r} x^{-3}dx = \frac{q}{4\pi\varepsilon_0}$$

From the definition of electric potential, this work is equal to the potential at point P,$V = \frac{q}{4\pi\varepsilon_0 r}$

A positively charged particle produces a positive electric potential. A negatively charged particle produces a negative electric potential.

What is Capacitance?

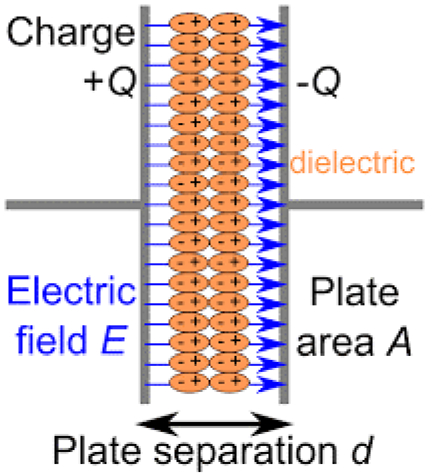
Capacitance is the ability of a component or circuit to collect and store energy in the form of an electrical charge. Capacitors are energy-storing devices available in many sizes and shapes.

Difference between capacitor and capacitance:

The ability of the capacitor to store charges is known as capacitance. Capacitors store energy by holding apart pairs of opposite charges. The simplest design for a capacitor is a parallel plate, which consists of two metal plates with a gap between them.

What is the principle of a parallel plate capacitor?

If we supply more charge, the potential increases and it could lead to a leakage in the charge. If we get another plate and place it next to this positively charged plate, then negative charge flows towards the side of this plate which is closer to the positively charged plate.



What is the difference between ohmic and non ohmic materials?

Non-ohmic conductors have a resistance that fluctuates with a change in the applied voltage, whereas ohmic conductors have a constant resistance that does not. This distinction is important in electrical circuit design and analysis because it influences how the current overflows and the operating voltage bears.

What are the ohmic materials?

The many substances for which Ohm's law holds are called ohmic. These include good conductors like copper and aluminum, and some poor conductors under certain circumstances. Ohmic materials have a resistance R that is independent of voltage V and current I.

What is an example of a non ohmic material?

There are a number of examples of non-Ohmic conductors; including bulb filaments and semiconductors like diodes and transistors. A diode provides a near constant voltage drop even if you vary the current, so it does not follow Ohm's law.