ELECTRICITY (Physics 2)

Introduction

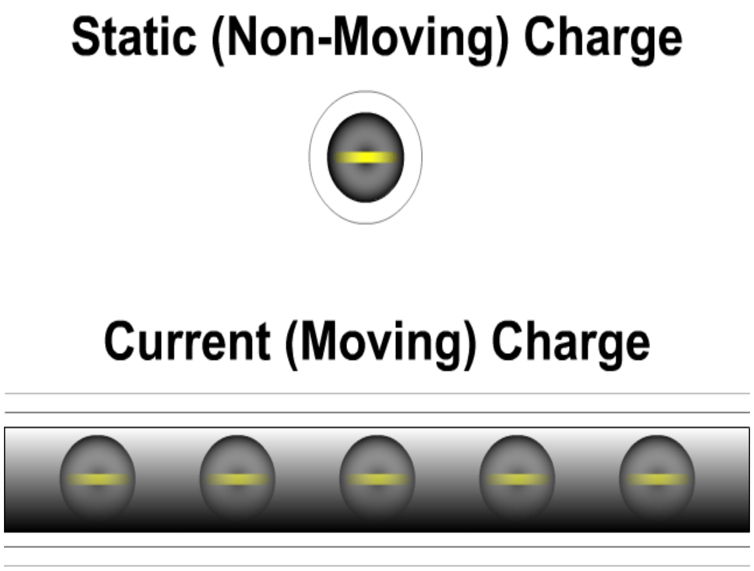
What is the difference between static electricity and current?

In **Static Electricity (Electrostatic)** , charges build up on an object but do not flow. Electrons move from one surface to another, creating an imbalance.

Electric Current involves the continuous flow of electric charge. Electrons move through a conductor, creating a flow of current.

Static (Non-Moving) Charges Creates an Electric Field.

Current (Moving) Charges Create a Magnetic Field



Electrification Experiments

Electrification (charging) represents a phenomenon of charge transfer. There are three types of electrification of an object by:

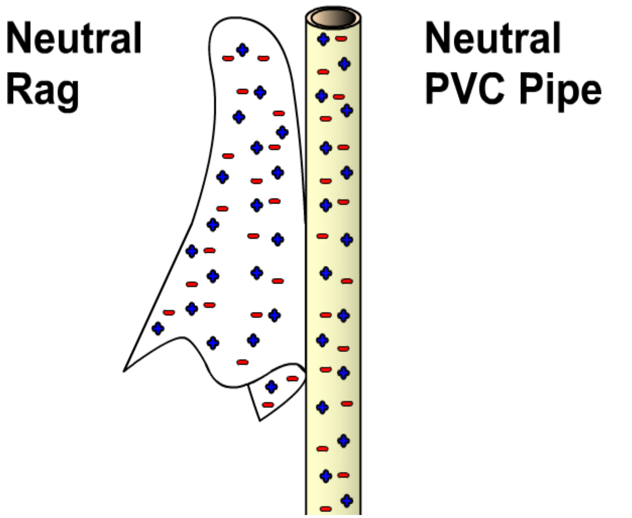
- **Friction**
- **Conduction (Contact)**
- **Induction (Influence)**

➢ Electrification (Charging) By Friction

Different materials have a different affinity for electrons. Some hold on to their electrons tighter than others.

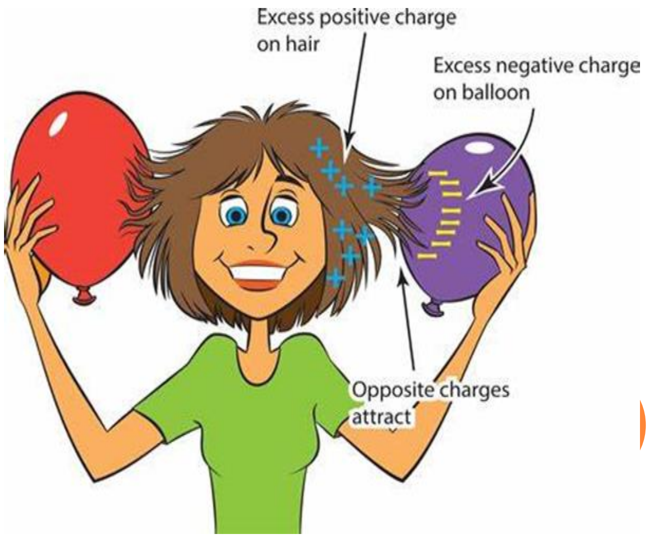
•**Greater affinity for electrons**: hold electrons **stronger** and often gain electrons by friction and **become negative**.

•**Less affinity for electrons**: hold electrons weaker and often loose more electrons by friction and **become positive**.



In this **experiment**, when we **rub** the balloon against our hair, we **transfer negative charge** to the balloon in the form of electrons.

This means that the balloon is now negatively charged, and our hair is positively charged. When we put the balloon by our hair, they attract because they are oppositely charged



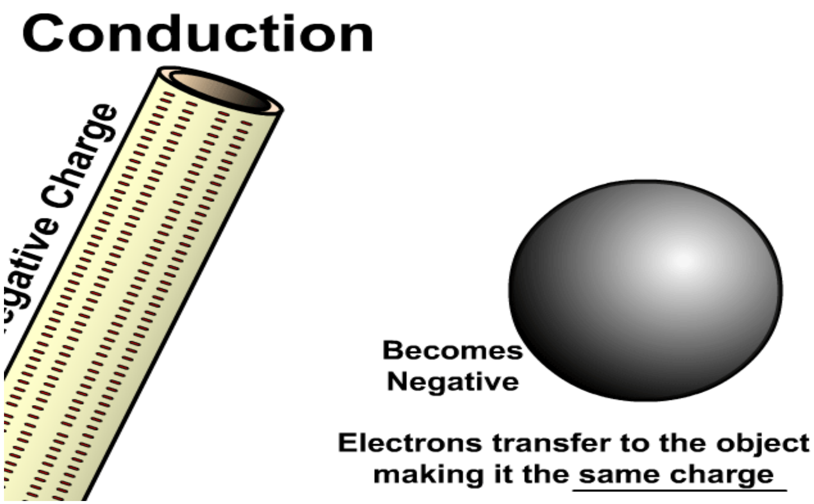
➢ Electrification By Conduction (contact)

Contact electrification occurs on a neutral object when a charged object is in contact with it.

During conduction the same charge is created in a neutral object. Electrons will transfer from a negative object to a neutral object making it negative.

Charging By Conduction Facts

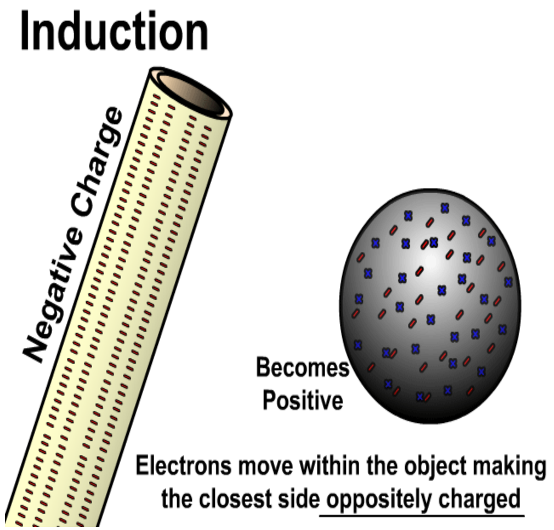
- **Contact**
- **Same** charge
- **Permanent** (with electron transfer)



➢ ELECTRIFICATION BY INDUCTION (**INFLUENCE**)

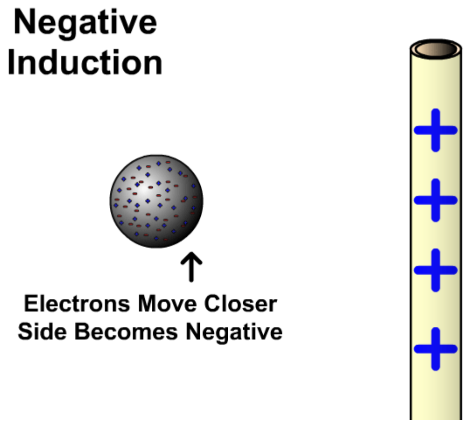
You can induce a charge in a neutral object by moving a charged object close to it.

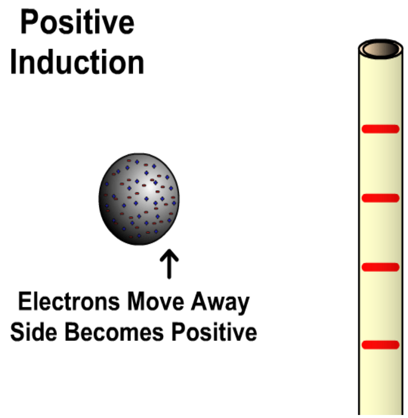
Induction electrification or influence creates a temporary and opposite charge in that other object with **no contact**. This is considered temporary because no electrons are transferred and neutrality returns when the close charged object is removed.



Charging By Induction Facts

- No contact
- Opposite charge
- Temporary (no electron transfer)

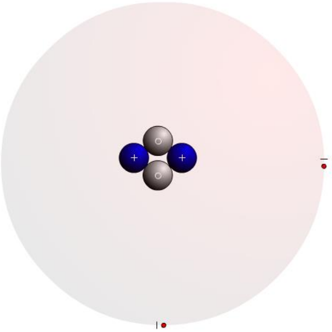




Electric Charge

Electric charge it is a scalar quantity, representing a fundamental property of matter that helps explain certain phenomena (electrostatics, electromagnetism, etc.).

There are two types of electric charge, positive and negative.



Elementary charge:

This is the smallest amount of charge

Q= |e| = $1.602176634\times10^{-19}$ C

the electrical charge of an:

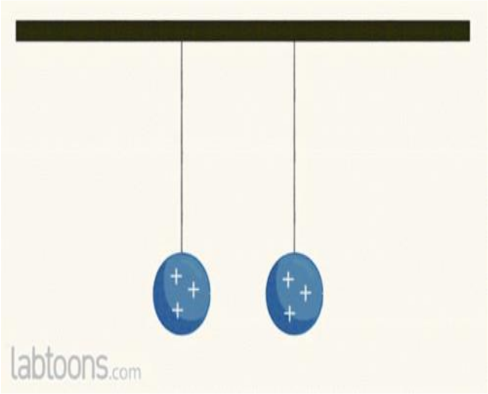
electron : $Q_e = -e = -1.602176634\times10^{-19}$ C

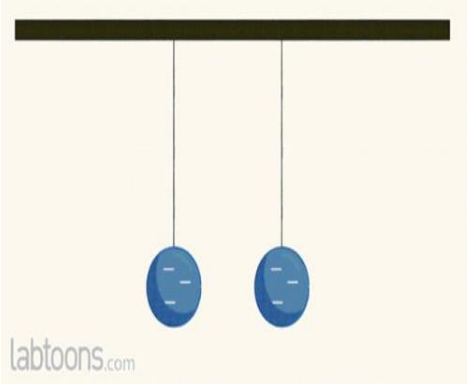
and

proton : $Q_p = +e = +1.602176634\times10^{-19}$ C

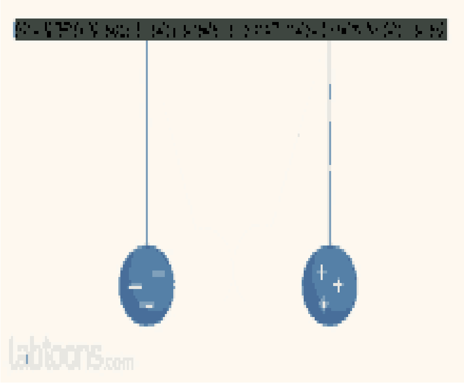
ELECTRIC CHARGE

Two charges of the same sign repel each other, and two charges of opposite signs attract each other.





repel



attract

- **Point charge** **:**it is an electric charge localized at a dimensionless point.

- **_conservation of electric charge** **:** In an isolated body, the algebraic sum of electric charges remains constant:

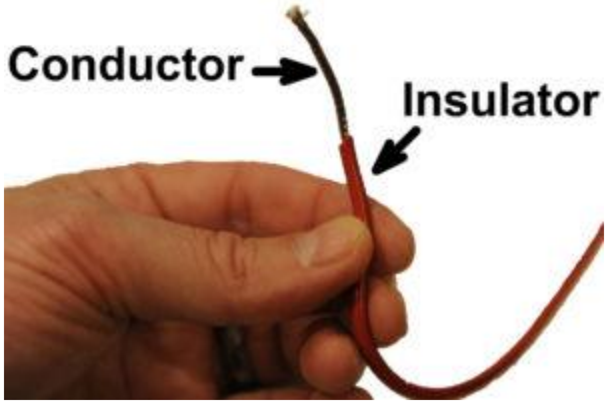
$$q_{final} = q_{initial}$$

3. Conductive and insulating materials

Two materials are distinguished: conductors and insulators.

a. **Conductive materials** :In conductors, electric charges are free to move and are distributed throughout the material. An electrical conductor therefore carries the electric current (iron, aluminum, salt water, etc.).

b. **Insulating materials (dielectrics) :** An electrical insulator is a medium that does not conduct electric current, as it does not allow the passage of free electrons from one atom to another (ebonite, glass, porcelain, plastics, etc.). The insulator becomes charged by friction.



COULOMBS LAW

a. Interaction between two point charges q1 and q2: Two charges $\mathbf{q_1}$ and $\mathbf{q_2}$ spaced **r** apart placed in a vacuum. The first exerts on the second a force F_{12}, the second exerts on the first a force F_{21}. Coulomb's law can be used to determine the electrostatic force, which is, written as :

$$\vec{F}_e = \vec{F}_{12} = -\vec{F}_{21} = K\frac{q_1 q_2}{r^2}\vec{u} \Rightarrow F_e = F_{12} = F_{21} = K\frac{|q_1|.|q_2|}{r^2}$$

where k is a constant and equals to $1/4\,\pi\,\varepsilon_0$. Here, ε_0 is the epsilon naught and it signifies permittivity of a vacuum. The value of **k** $= 9 \times 10^9$ Nm^2/C^2 when we take the S.I unit of value of ε_0 is $8.854 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$.

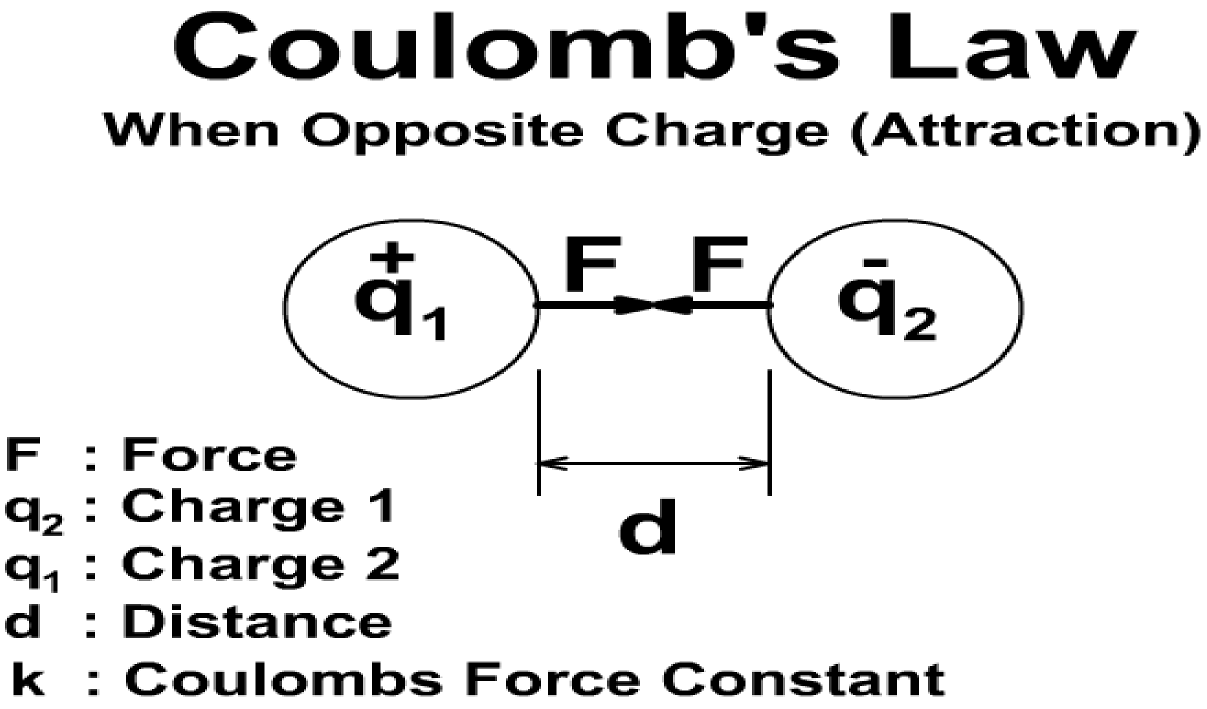
<u>Note</u>: **In a medium other than vacuum, ε_0 will be replaced by $\varepsilon = \varepsilon_0\varepsilon_r$ where εr represents the relative permittivity, so the force is given by the following relationship:**

$$\vec{F}_e = \frac{q_1 q_2}{4\pi\varepsilon_0\varepsilon_r r^2}\,\vec{u} \Rightarrow F_e = \frac{|q_1|.|q_2|}{4\pi\varepsilon_0\varepsilon_r r^2}$$

<u>**So,**</u>

If the two charges have the same sign then the force is **repulsion force**

If the two charges have different signs, then the force is **attraction force**



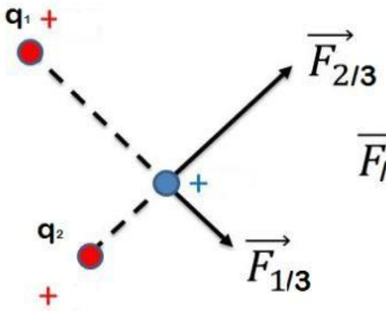
Exercice

- Calculate the force exerted by a load $q_1= 5.\ 10^{-4}$ C on a load $q_2 = 2.10^{-4}$ C separated by a distance r = 3 mm.
- So, we have………

SUPERPOSITION PRINCIPLE OF COULOMB'S LAW

Assuming that there exist n immobile electric charges in a vacuum. Electrostatic force exerted by the n charges on a charge q located at a point **M** is :

The superposition principle allows us to determine the **total force** on a given charge due to any number of point charges acting on it.



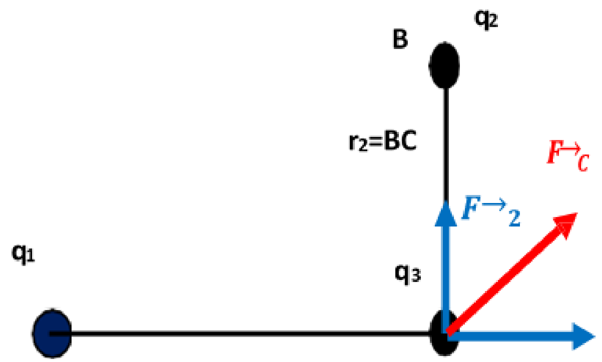
$$\overrightarrow{F_{/3}} = \overrightarrow{F_{total}} = \overrightarrow{F_{1/3}} + \overrightarrow{F_{2/3}}$$

Exemple :

On place respectivement aux points A, B et C les charges q1=1.5 10-3C, q2= -0.5 10-3C et q3=103C. On donne AC=1m et BC=0.5m. Calculer la force exercée sur la charge q3?

Solution

F=22.5 10^3 C



THE ELECTROSTATIC FIELD

Electric Fields

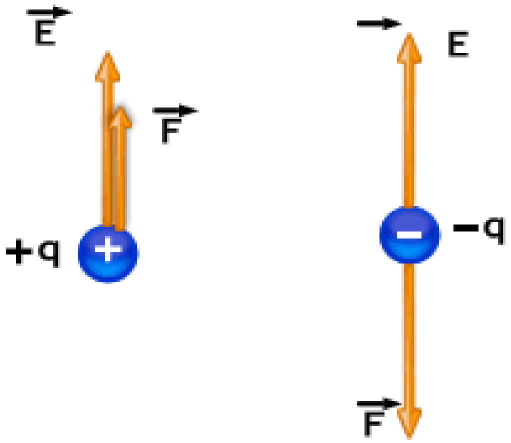
A static charge on an object will create an electric field. Learn to draw electric fields around single and multiple charges and solve for their value.

The basics of the electric field

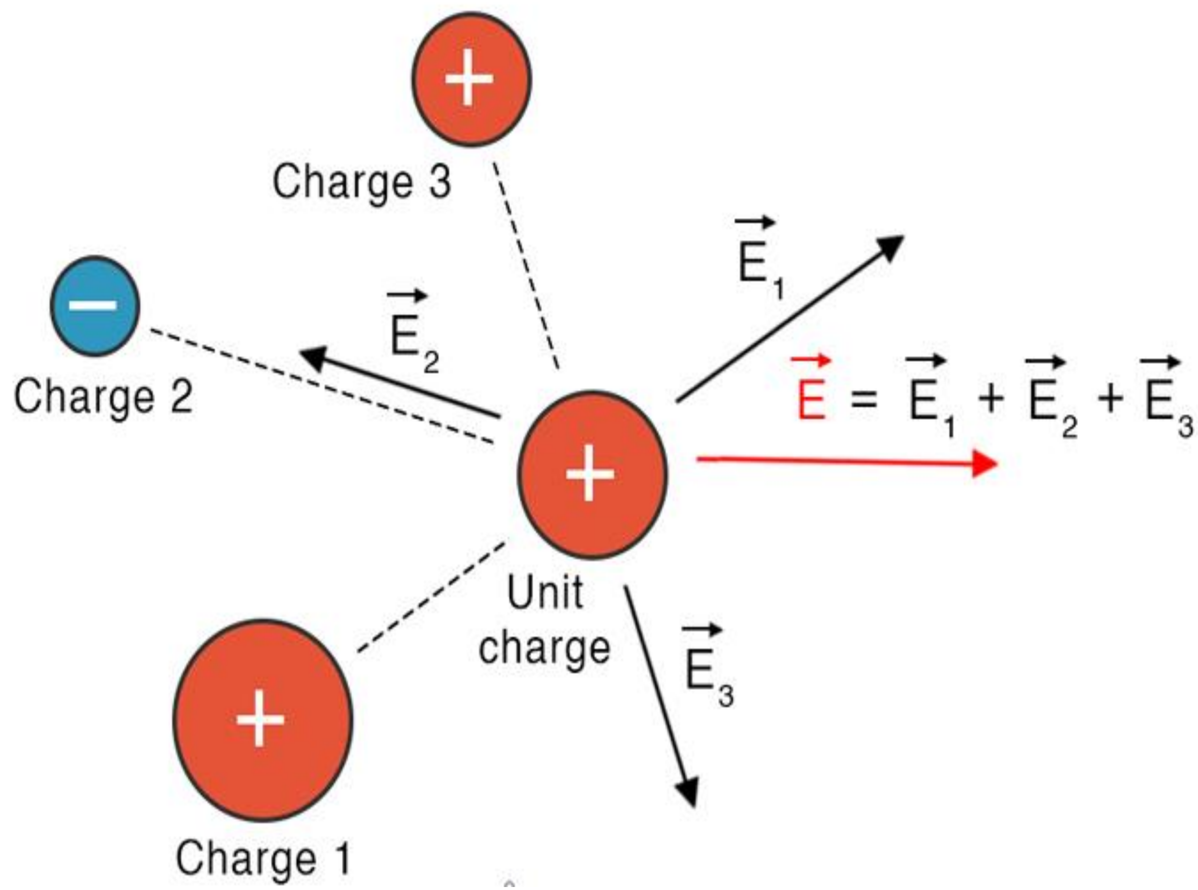
- Electric field (E): area of electrical influence around a charged object.
- Variable (E)
- Unit: newton per coulomb (N/F)

$$E = \frac{F}{q}$$

$$E = \frac{kq}{d^2}$$



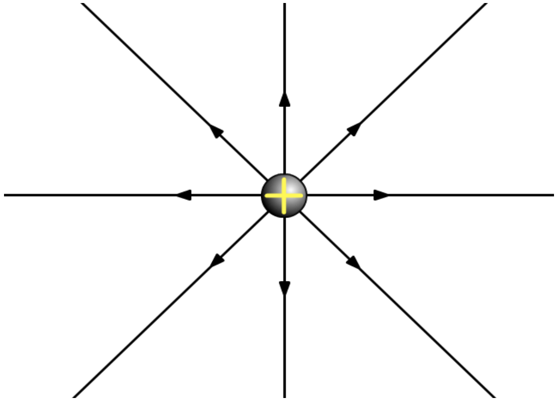
Superposition of Electric Fields



. **Field Lines**

Field lines are curves where the electrostatic field is tangent at each point

The lines for a positive charge point away from the charge



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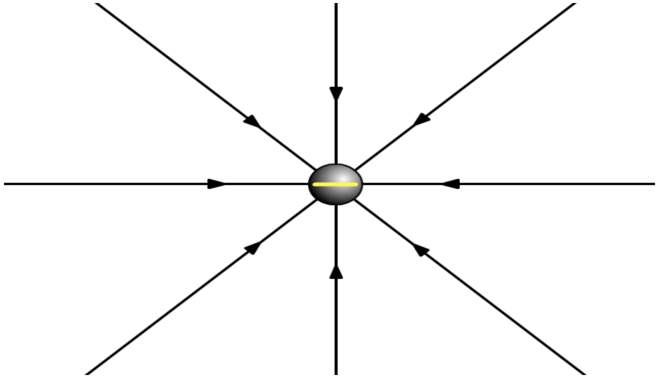

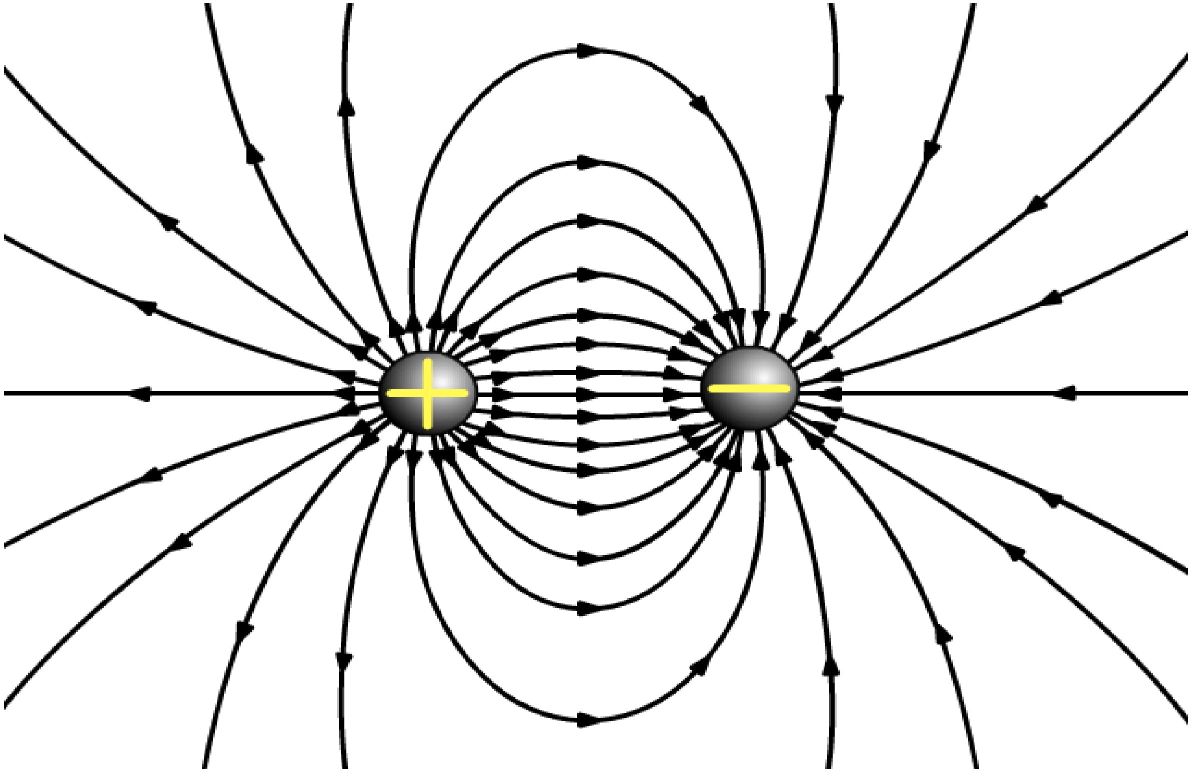

Example

At the vertices of a square ABCD with dimensions a=1cm, the charges qA = 2μC, qB = -4μC, qC = 2μC and qD = 1μC are placed.

-Calculate the modulus of the field at point O intersection of the diagonals.

Solution

$E_O = 9.10^8\ V/m$