Electric Fields

An electric field is created by a charged object.

This electric field can be measured by placing a charge within the field and measuring the force between the charged object and the test charge.

Equation: $E = \frac{F_{on\ q'}}{q'}$

The strength of the electric field is independent of the test charge (q').

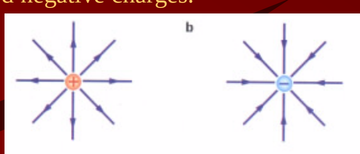
Examples

1. A positive test charge of 4.0×10^{-5} C is placed in an electric field. The test charge experiences a force of 0.60 N. What is the strength of the electric field at this point?
2. A 5.0×10^{-4} C charge produces an electric field. The test charge of 7.5×10^{-5} C is placed within the electric field, 0.4 m away from the charge. What is the strength of the electric field at this point?

Picturing Electric Fields

Electric fields can be pictured as lines drawn tangent to the charge, like spokes on a wheel.

Field lines move away from positive charges, and toward negative charges.



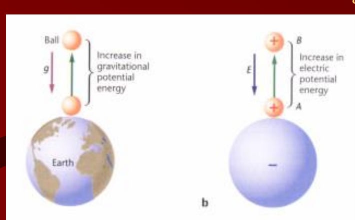
Electric Field Lines

When two charges are near one another, their fields interact. The new field is the vector sum due to the individual charges. The field lines become curved.

These lines do not exist. They are imaginary. They just help us to visualize an electric field.

Electrical Potential

Suppose that it was necessary to move a test charge in an electric field. In order to move that charge, work would need to be done to the charge.

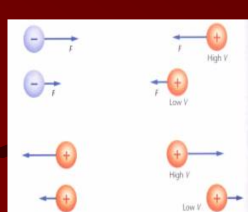


Electrical Potential Difference

The change in electrical potential due to the movement can be calculated by:

$$\otimes V = \frac{W_{on\ q'}}{q'}$$

Electric potential difference (⊗V) is measured in J/C, or what we commonly in Volts (V)



Example

1. A +1.6 x 10^{-5} C test charge sits in an electric field. The test charge is moved in the electric field by applying a force of 2 N as it is pushed 0.3 m away. What is the potential difference?
2. A +1.6 x 10^{-5} C test charge is placed in an electric field of 300 N/C. The test charge is repelled by the field 15 cm. What is the potential difference caused by the movement?

Uniform fields

It is possible to set-up uniform fields between two plates, where the force on a test charge will be the same throughout the field.

When two parallel plates are set-up with opposing charges, the potential increases as you move the test charge toward the plate with the same charge.

In an uniform field: $\otimes V = Ed$

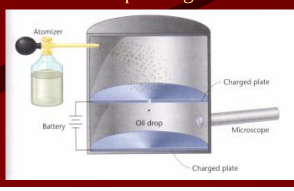
Example

A +1.6 x 10^{-5} C test charge sits in an electric field. The test charge is moved in the 800 N/C electric field from one plate to the other. The plates are 30 cm apart. What is the potential difference?

Millikan's Oil Drop Experiment

Millikan first determined the charge of an electron by using uniform electric fields. When the oil drops went through a properly charged plate, the oil drop could be suspended in midair. Since gravity and repulsion are equal, the relationship is:

$$qE = mg$$



Example

A drop of oil is suspended in an electric field. The field is 4500 N/C. The mass of the oil drop is found to be 3.7×10^{-16} kg.

a) What is the charge of the drop?

b) The charge is a result of excess electrons on the drop. If an electron has a charge of 1.6×10^{-19} C, how many electrons are on the drop?

Capacitors

Charges can be stored in an object called a capacitor in order to be used at a later date.

Capacitance is a measure of the amount of charge on an object. It is dependent only on the potential difference across the object.

$$C = q/\Delta V$$

Capacitance is measured in Farads (F). The larger the object, the greater the capacitor.

Example

Both a 3.3 μF (3.3×10^{-6} F) and a 6.8 μF capacitor are connected across a 15 V electrical potential difference. Which capacitor has a greater charge? What is that charge?

Sharing of Charge

All systems want to come to equilibrium.

Different sized objects can have different voltages