

Topics Discussed

Electric Charges and forces, Coulomb's Law,
Electric field from multiple charges - the superposition principle

Fundamental charge, e

The fundamental unit of charge is $e = 1.602\,176\,63 \times 10^{-19}$ Coulomb
and the charge on the electron is
 $q_e = -e$ and the charge on the proton is $q_p = +e$.

One Coulomb is an *enormous* charge. As we saw in class, if charge accumulates to a significant extent, the electric field can grow so large as to rip electrons off air molecules and allow lightning bolts to travel through the air. This is known as *dielectric breakdown*.

Coulomb's Law

The **magnitude** of the electrical force between two charges is given by

$$|\vec{F}| = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} = \frac{k q_1 q_2}{r^2}$$

where r is the distance between the charges, and Coulomb's constant,

$$k = \frac{1}{4\pi\epsilon_0} = 8.987\,551\,792\,3(14) \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$$

and

$$\epsilon_0 = 8.854\,187\,82 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$$

is called the permittivity of free space.

Fundamental Charge

The fundamental charge is the charge on an electron (or a proton), whose **magnitude** is

$$e \approx 1.602 \times 10^{-19} \text{ C}$$

Electric Field

A charge q sets up an electric field in space described by

$$\vec{E} = \frac{kq}{r^2} \hat{r}$$

where r is the magnitude of the vector which goes *from* the charge q *to* the field point. \hat{r} is a *unit vector* in this direction. Remember, any vector \vec{r} can be turned into a unit vector via

$$\hat{r} = \frac{\vec{r}}{|\vec{r}|}$$

Superposition principle

The electric field at any point in space is the vector sum of the electric fields from each of the charges.