Lecture one

Electric Charge

- The unit of electric charge is the Coulomb (abbreviated C). Ordinary matter is made up of atoms which have positively charged nuclei and negatively charged electrons surrounding them. Charge is quantized as a multiple of the electron or proton charge:

Proton charge $e = 1.6 \times 10^{-19}$ Coulombs •

electron charge $-e = -1.6 \times 10^{-19}$ Coulombs •

Insulators and Conductors

Conductor: A material whose conduction electrons are free to move throughout. Most metals are conductors.

Insulator: A material whose electrons seldom move from atom to atom. Most insulators are non-metals.

Coulomb's Law

Coulomb's law gives the force between two point charges:

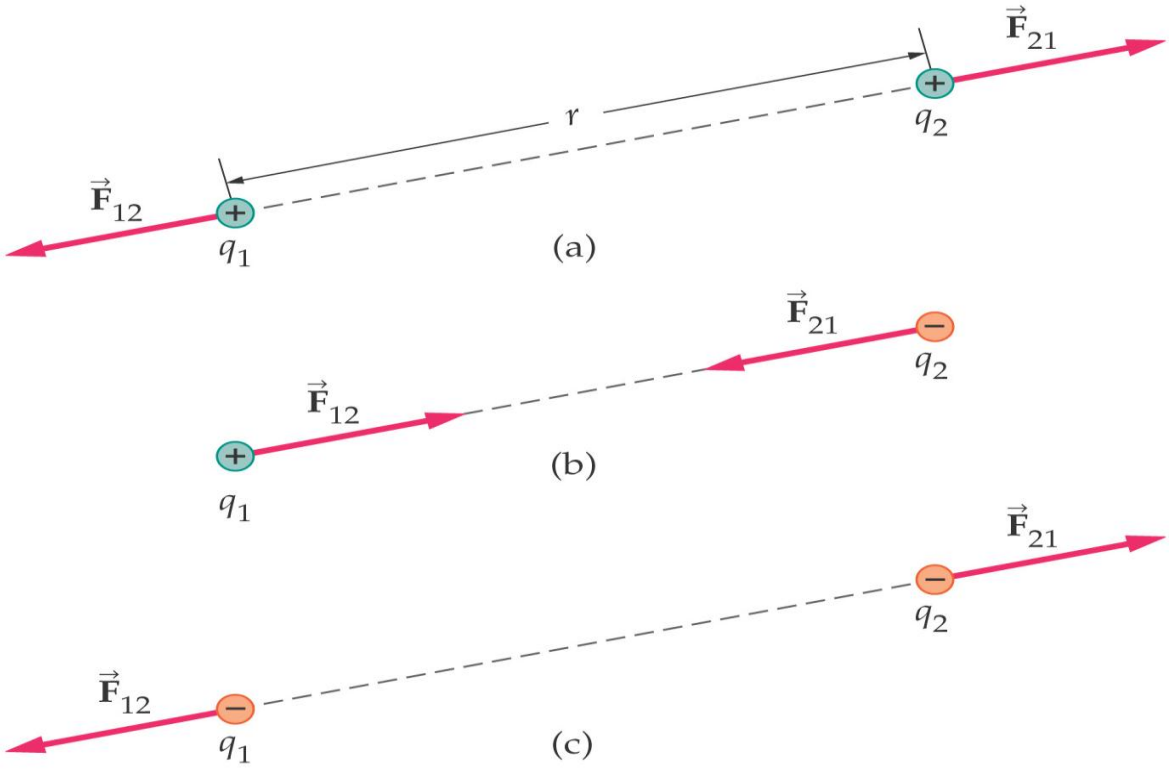
$$F = k\frac{|q_1||q_2|}{r^2}$$

SI unit: newton, N

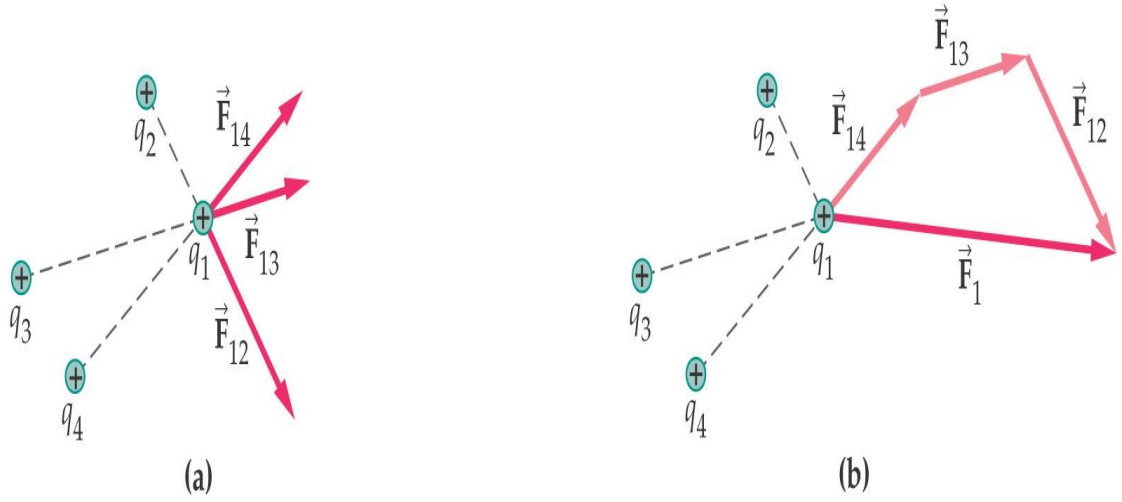
$$k = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$$

The force is along the line connecting the charges, and is attractive if the charges are opposite and repulsive if the charges are like.

The forces on the two charges are action-reaction forces.



If there are multiple point charges, the forces add by superposition.



Coulomb's law is stated in terms of point charges, but it is also valid for spherically symmetric charge distributions, as long as the distance is measured from the center of the sphere.

Example for Coulomb's law

- What is the electric force between 2 *u*-quarks separated by 1.0E-16 meters? This is a typical separation inside a proton.
- Given: The charge of an up quark is *(2/3)e*.
  Solution:
  The force between the two charges is given by Coulomb's law:

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

SI unit: newton, N

where r = 1.0E-16 (m) , $q_1 = q_2 = (2/3)*e$

Hence F = 1.03E4 (N)

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