Electric charge, electrostatic force, and electric charge transfer

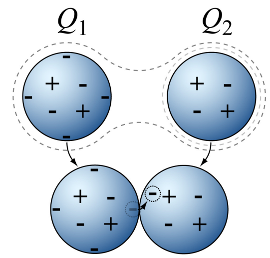
Electric charge exists.

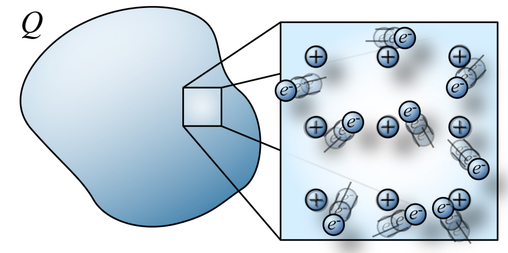
Electric charge – All objects have a postulated signed scalar quantity, called electric charge, measured in Coulombs.

$$[Q] = \mathrm{C}$$

Charge is conserved –

$$\Sigma Q_i + \Delta Q_{\mathrm{EXT}\rightarrow\mathrm{SYS}} = \Sigma Q_f$$





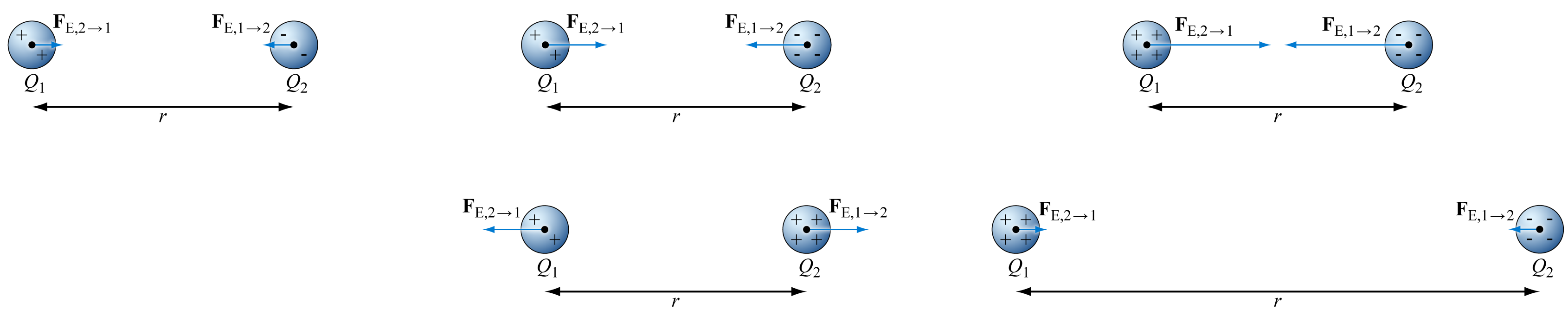
Charges in materials – In solid materials commonly encountered in daily life, positively-charged ions are relatively stuck in place. Some electrons are somewhat looser. **Conductors** are materials that contain an abundance of electrons that are “very free” to move. **Insulators** are materials that do not contain any electrons that are “very free” to move.

$$q_{\mathrm{ELECTRON}} = -e, \qquad q_{\mathrm{PROTON}} = +e$$

$$e = 1.60 \times 10^{-19}\ \mathrm{C}$$

$$Q = ne, \qquad n = \cdots, -2, -1, 0, 1, 2, \cdots$$

Objects with electric charge can exert electrostatic forces on each other.



Coulomb’s law – for stationary point (and/or spherically symmetric) charges,

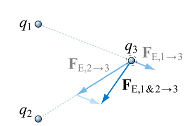
$$\left|\vec{\mathbf{F}}_{\mathrm{E},1\rightarrow 2}\right| = k\frac{|q_1||q_2|}{r^2}$$

$$k := \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \frac{\mathrm{N\ m}^2}{\mathrm{C}^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\mathrm{C}^2}{\mathrm{N}\cdot\mathrm{m}^2}$$

$\left.\begin{matrix} +,+ \\ -,- \end{matrix}\right\}$ Repulsion

$\left.\begin{matrix} +,- \\ -,+ \end{matrix}\right\}$ Attraction



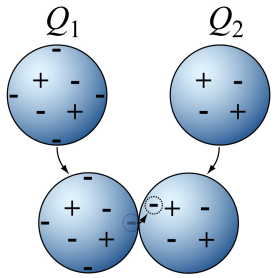
Superposition

$$\vec{\mathbf{F}}_{\mathrm{E},1\&2\rightarrow 3} = \vec{\mathbf{F}}_{\mathrm{E},1\rightarrow 3} + \vec{\mathbf{F}}_{\mathrm{E},2\rightarrow 3}$$

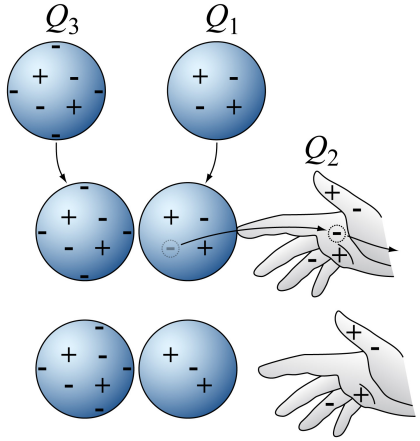
Electric charge, electrostatic force, and electric charge transfer

Electrostatic forces can contribute to changes in spatial arrangements of electric charge.

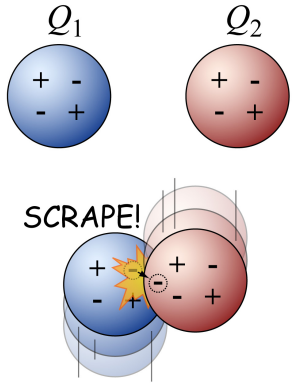
Transfer of charge by conduction – transfer of charge between two objects in contact that reduces the magnitude of the net charge of at least one of the objects



Transfer of charge by induction – transfer of charge from one object to a second object that the first object touches owing to proximity of a third object that touches neither of the first two objects

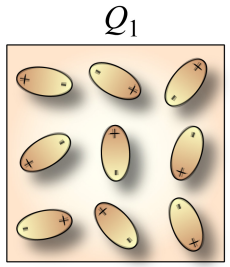


Transfer of charge by friction – transfer of electrons through scraping from one object to another object that more easily grabs onto electrons



Polarization – A charged object causes the closer side of a nearby neutral object to develop a charge of opposite sign and causes the farther side of the neutral object to develop a charge of the same sign. This can result from transport of electrons, from alignment of molecular dipoles, or from a combination of both effects.

Unaligned



Aligned (by introduced external charge)