

Electric Charges and Fields

one law between two charges, one field mapping the space around them

Charge

q

the source, quantised and conserved

→ defines

Force

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

Coulomb's law, on q_2 due to q_1

→ defines

Field

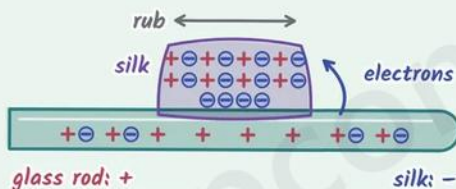
$$E = \frac{F}{q_0}$$

force per unit +test charge

run it back: E gives $F = q_0 E$ on any charge; Coulomb's law is this field for a point source

Charge, properly

- rubbing moves electrons: glass rubbed with silk turns +, the silk -, by equal amounts
- additive: net charge is the plain scalar sum, signs included
- conserved: the total charge of an isolated system never changes; charge is only moved
- quantised: $q = ne$, n an integer, $e = 1.6 \times 10^{-19}$ C the smallest free charge

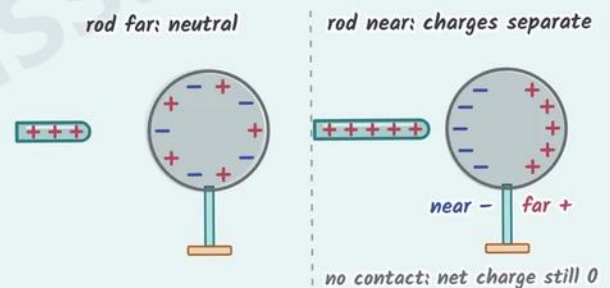


total charge 0: conserved
charge comes in whole electrons: $q = ne$

rubbing moves electrons from glass to silk: glass +, silk -, the total stays 0

Conductors and induction *

- conductors let charge move (metals, earth, body); insulators hold it (glass, plastic)
- induction: a charged rod nearby shifts free electrons, near side opposite, far side the same
- rod near, earth on, earth off, rod away: a charge opposite to the rod's stays
- conduction needs a touch; induction never does

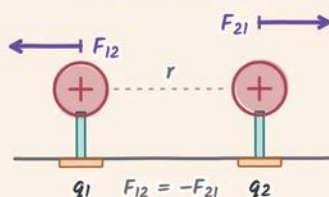


bring a charged rod near: the free electrons shift, near side opposite, far side the same; nothing touched, net charge still 0

Like charges vs unlike charges

Like charges

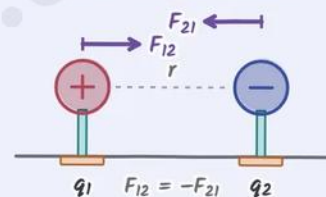
like charges repel



- repel: same sign, $q_1 q_2 > 0$

Unlike charges

unlike charges attract



- attract: opposite sign, $q_1 q_2 < 0$

either way the two forces are equal and opposite: Newton's third law holds for Coulomb forces too