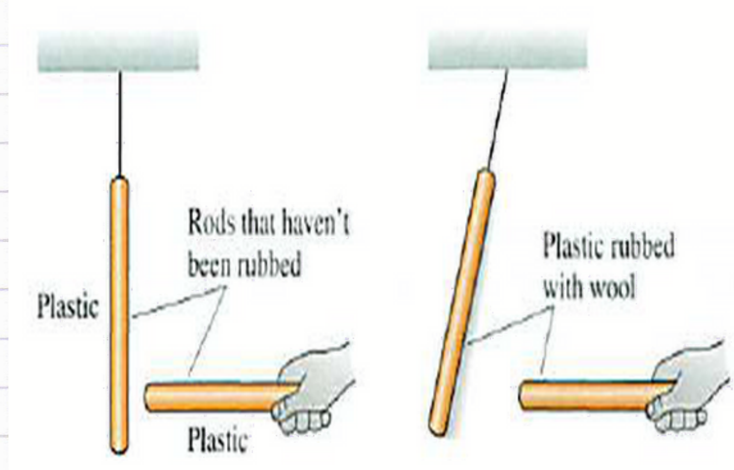
# Static electricity




## charge model

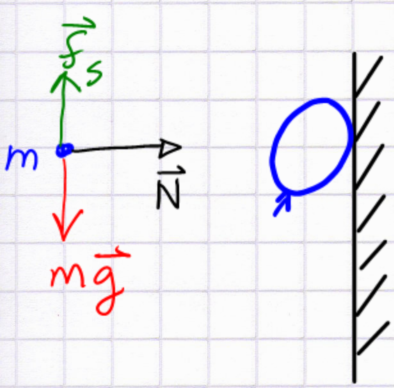
step 1 : play around and observe phenomena

rubbing amber (2000 yrs ago!) or plastics (more effect!)

leads to puzzling phenomena :

comb passed through hair → picks up small paper pieces

inflated balloons, or, styrofoam cup pieces rubbed → stick to vertical walls




$$|\vec{f}_s| \le \mu_s |\vec{N}|$$

where does this "big" normal force come from ?

For some materials : separated charge is stuck in place → insulators (rubber, plastic, wood)

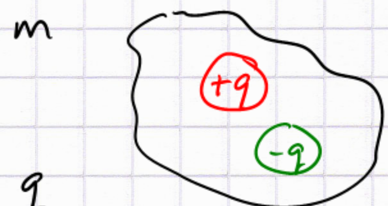
other materials : rubbing with fur, cloth, ... doesn't do much, but charge can be taken away

- ↗ metals = electron conductors
- ↘ salty solutions = ionic conductors

An idea is born:

matter is not only mass $m$, but also has the property of charge; charge is of two kinds: $+q$, $-q$

Normally: contains equal amounts of $\pm q$




this object is charge neutral

Until 1900's: charge is believed to be equally smeared in the building blocks (atoms)

Rutherford scattering expt. (came to McGill!)

charged particles (from radioactive decay; $He^{++}$ nuclei) collide with thin gold foil

→ excess of large-angle scattering, incl. back scattering

→ new model of the atom: + tiny nucleus & − charged smeared cloud

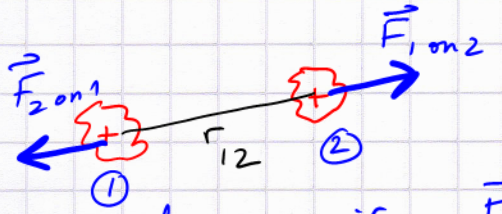
The negative electron cloud: allows transfer of charge when bringing two materials in contact

→ frictional (tribo-) electricity

# Forces between charges → Coulomb's law

- start with the repulsion of like-charged objects (see figure @ top of p. 1)

- establish how the force depends on the distance between the objects → easy → similar to Cavendish torsion balance for gravity




Coulomb establishes : force $\sim \frac{1}{r_{12}^2}$

force pair $\vec{F}_{1 \text{ on } 2}$ and $\vec{F}_{2 \text{ on } 1}$ = action-reaction pair

$$|\vec{F}_{1 \text{ on } 2}| = |\vec{F}_{2 \text{ on } 1}| \sim \frac{1}{r_{12}^2}$$

Note : for this to be true :

- amount of net + charge on (1) and (2) does NOT need to be the same for $|\vec{F}_{1 \text{ on } 2}| = |\vec{F}_{2 \text{ on } 1}|$ to hold !
- the masses $m_1$ and $m_2$ play no role as long as the objects are kept in equilibrium (by torsional wire force)
- we refer to net + charge, most of the bodies $m_1$ and $m_2$ contain $\sim 10^{24}$ neutral atoms, a small amount of electrons was stolen by some cloth

Coulomb : $$|\vec{F}_{1 \text{ on } 2}| = |\vec{F}_{2 \text{ on } 1}| = K \frac{q_1^{net} q_2^{net}}{r_{12}^2}$$

K: Coulomb constant

**Units:** Coulomb unit for charge is derived from force when objects are held 1m apart

→ 1 C = 1 Coulomb = huge charge

typical frictional charge separation:

nano Coulomb $nC = 10^{-9}\,C$

later: $1\,C = 1\,As$ Ampère second

relates to electric current: 1 Amp flows for 1 sec → 1 C of charge passed through cross section

$$K \approx 9.0 \times 10^{9}\,\frac{Nm^2}{C^2}$$

almost 3-digit accuracy (8.99)
→ good enough for us!

- product $q_1 \cdot q_2$ can be positive/negative

→ attraction and repulsion occur → gravity knows only attraction.

- charge polarization (attraction of a neutral by a charged object)

new when compared to gravity. force $\sim \frac{1}{r^3}$ (why?)

Fundamental particles? $e^-$: $m = 9.11 \times 10^{-31}\,kg$
$q = -1.60 \times 10^{-19}\,C$