2 kinds of charge: "positive" & "negative"

by convention: nucleus +
electron -

like charges repel, opp attract

Total change of isolated system is conserved.

Coulomb's law:
\[ F = k \frac{q_1 q_2}{r^2} \]

where \( q \) is measured in arbitrary, empirically defined unit, Coulomb (C)

\[ k = 8.99 \times 10^9 \, \frac{N \cdot m^2}{C^2} \]

repulsive force between 2 1C charge 1m apart is equivalent to weight of 1 billion kg = 1 million metric tons

\[ F \quad \leftarrow \quad + \quad + \quad \rightarrow \quad F \]
Fundamental unit of charge on electron: \( q_e = -e \) where 
\[ e = 1.6 \times 10^{-19} \text{C} \]

Deep reason why \( q_p + q_e = e - e = 0 \)

Bulk matter is neutral

\[ \frac{ke^2}{Gm_p^2} = 10^{39} \]

Compare:

Even tiny different between \( q_p \) and \( q_e \) would give huge repulsive force to bulk matter.

Conductivity - mobility of electrons (\( e^- \)) in material.

Conductor

Metal have "free" highly mobile \( e^- \), allowing charge (\( e^- \) or charged "hole" to move)

Static charge resides on surface where like charges are as far apart as possible.
insulator -
charge does not move but attaches
("sticks") to surface

Ground - Any large reservoir of charge,
such as the earth.

\[ \text{charged sphere} \]
\[ \text{conducting (copper) wire} \]
\[ \text{symbol for ground} \]

Conducting charged sphere will immediately
discharge when connected to ground.

Insulating material is hard to discharge
Superposition

\[ \vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 \] vector addition

\[ R_{\text{net}} = R_1 + R_2 \] Very small test charge

two fixed charges

5. The Electric Field (vector)

\[ \vec{E} \] acts locally to produce force "Communicate" charge in change position

\[ \vec{E} = \frac{\vec{F}}{q} \]

\[ \vec{E} = \frac{F}{q_{\text{test}}} = \begin{cases} \frac{kq}{r^2} & \text{if } q \neq 0 \text{ is not there} \\ \vec{E} \text{ "exists"} & \end{cases} \]

\[ \vec{E} \text{ is used to probe or map the field.} \]