## Electric Charge

Electric charge can be positive or negative. It is quantized in units of $e - 1.6\times10^{-19}C$. It is conserved, i.e. the total charge of an isolated system is conserved.

Electric & Magnetic Forces act on charged particles ⟵ Charged particles cause ⟶ electric & magnetic forces.

## Coulomb's Law

$$\underline{F} = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{r^2}\hat{r}$$

$\varepsilon_0$ = permittivity of free space

## Principle of Superposition

What is the force on q if there are charges $Q_1, Q_2, Q_3 \ldots Q_N$.

$$\underline{F} = \frac{1}{4\pi\varepsilon_0}\frac{qQ_1}{r_1^2}\hat{r}_1 + \frac{1}{4\pi\varepsilon_0}\frac{qQ_2}{r_2^2}\hat{r}_2 + \ldots + \frac{1}{4\pi\varepsilon_0}\frac{qQ_N}{r_N^2}\hat{r}_N$$

$$\underline{F} = \frac{q}{4\pi\varepsilon_0}\sum_{n=1}^{N}\frac{Q_n}{r_n^2}\hat{r}_n$$

## Electric Field

Coulomb's law interpretation implies that charges create forces. Q creates a field. The force on q is exerted by the field.

$$\underline{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$$

$\underline{E}$ is a vector field (strength & direction). If $Q > 0$, $\underline{E}$ points away from charge. If $Q < 0$, $\underline{E}$ points towards charge.

A charge $q$ in the field experiences the force

$$\underline{F} = q\underline{E}$$

- Superposition still applies
- $Q_i$ creates field $\underline{E}_i$
- for $n$ particles $\underline{E} = \underline{E}_1 + \underline{E}_2 + \ldots + \underline{E}_n$

## Field Lines

A tool to map out $\underline{E}$ in space. The field line is tangent to $\underline{E}$ at every point in space.

The field is parallel to the line element at every point. $\underline{dl} \parallel \underline{E}$. $\underline{dl}(x,y,z) = \underline{E}(x,y,z)$

$$dx = E_x \quad dy = E_y \quad dz = E_z$$

$$\frac{dx}{E_x} = \frac{dy}{E_y} = \frac{dz}{E_z}$$ } non examinable.