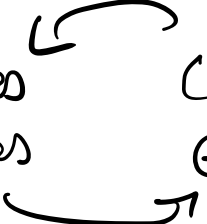


## Electric Charge

Electric charge can be positive or negative. It is quantized in units of  $e = 1.6 \times 10^{-19} \text{C}$ . 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

$$\underline{F} = \frac{1}{4\pi\epsilon_0} \frac{qQ}{r^2} \hat{r}$$

$\epsilon_0$  = permittivity of free space

## Principle of Superposition

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

$$\underline{F} = \frac{1}{4\pi\epsilon_0} \frac{qQ_1}{r_1^2} \hat{r}_1 + \frac{1}{4\pi\epsilon_0} \frac{qQ_2}{r_2^2} \hat{r}_2 + \dots + \frac{1}{4\pi\epsilon_0} \frac{qQ_N}{r_N^2} \hat{r}_N$$

$$\underline{F} = \frac{q}{4\pi\epsilon_0} \sum_{n=1}^N \frac{Q_n}{r_n^2} \hat{r}_n$$

## Electric Field

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

$$\underline{E} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}$$

$\underline{E}$  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  $\underline{E} = \underline{E}_1 + \underline{E}_2 + \dots + \underline{E}_n$

## 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,  $d\mathbf{l} \parallel \underline{E}$ .  $d\mathbf{l}(x,y,z) = \underline{E}(x,y,z)$

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

$$\frac{dx}{E_x} = \frac{dy}{E_y} = \frac{dz}{E_z} \quad \left. \vphantom{\frac{dx}{E_x} = \frac{dy}{E_y} = \frac{dz}{E_z}} \right\} \text{non examinable.}$$