The space where electric forces exist is called the **electric field**
We can verify the existence of electric field by placing a very small “probe” positive charge between the two “big” (“source”) charges.
The probe charge would move along the “electric force lines”.

The top ball (charged negatively) attracts the test charge. The bottom ball (charged positively) repels the test charge.
Electric field strength

The force applied to the probe charge q,

\[ F = k \frac{qQ}{r^2} \]

depends on the probe charge value (\( \sim q \))

To characterize the **strength of the electric field** created by the source charge Q (independently on the probe charge), we divide the force by the probe charge q. The result is called “electric field strength”, or simply “electric field” E:

\[ E = \frac{F}{q} = k \frac{Q}{r^2} \]
Electric field summary

\[ E = \frac{F}{q} = k \frac{Q}{r^2} \]

The electric field \( E \) is the electric force per unit charge.

Electric field has the **magnitude** and the **direction** (it is a vector)

The direction of the field is the direction of the force it would exert on a positive test charge.

In other words, the electric field direction is from positive toward negative charges.

The units for electric field are \( \text{N/C} = \text{(Force/charge)} \)

(note: \( \text{N/C} \) is NOT a commonly used unit for the electric field in SI; more common unit will be introduced later)
Electric field

The electric field of a positive point charge $Q$

The electric field is directed outward from a positive source charge.
Electric field

The electric field of a negative point charge Q

The electric field is radially in toward a negative source charge.
Example problem

Given the source charge $Q_{\text{source}} = 1 \text{ mC}$.

The test charge is located at the distance $r = 1 \text{ mm}$ below the source charge as shown.

Find the magnitude and the direction of the electric field at this point.

Solution

$$E = k \frac{Q}{r^2} \quad \text{where} \quad k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

$$E = 9 \cdot 10^9 \cdot 10^{-3} / (10^{-3})^2 = 9 \cdot 10^{12} \text{ N/C}; \text{ directed down}$$
Electric Force - Electric Field relationship

The electric field definition is

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

If the electric field, \( E \), is known, the electric force \( F \) exerting on the charge \( q \) placed in the field can be found:

\[ F = E \times q \]