**CHARACTERISTICS OF ELECTRIC FORCES (COULOMB’S LAW)**

The electric forces that two point charges (shown as small dots in the diagram below) exert on each other is found to depend on only three features of the situation. They are: the separation \( r \), and the two amounts of charge \( q_1 \) and \( q_2 \). This mathematical model of the electric force is called *Coulomb’s Law*.

**Dependence on the separation \( r \)**

The magnitude of the electric force \( F_{12} \) that charge \( q_2 \) exerts on charge \( q_1 \) gets smaller as the two charges are moved apart. The Coulomb force is found to be inversely proportional to the square of the separation \( r \) between the two point charges, as shown in the graph to the right.

**Dependence on the charges \( q_1 \) and \( q_2 \)**

The size of the Coulomb force increases as the size of each of the two charges increases. The force is proportional to the product of the two charges, \( q_1 \) and \( q_2 \).

**Coulomb’s Law**

The Coulomb force depends on a proportionality constant \( k \). In a vacuum, \( k \) has a value of about \( 8.99 \times 10^{9} \text{N} \cdot \text{m}^{2}/\text{C}^{2} \), where the standard MKS unit of charge is the *Coulomb* (C). (The size of the charge on an electron or proton is about \( 1.6 \times 10^{-19} \text{C} \).) In air, the value of \( k \) is slightly smaller, but we usually ignore this difference.

**Finding the direction**

The electric force always points parallel to the line that connects the two charges. When the product of the two charges is positive, the interaction is repulsive, and the force points directly away from the other charge (not shown). When the product is negative, the interaction is attractive, and the force points directly toward the other charge (shown).

**Dependence on multiple charges**

Electric forces obey the *Superposition Principle*. This means that the total electric force on any one charge is the vector sum of all the interactions between that charge and all other charges. In this example, there are three point charges, and therefore, two electric forces on charge \( q_1 \). Their vector sum is labeled \( \mathbf{F} \).