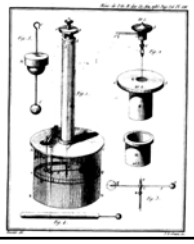
Coulomb's Law

- An electric charge exerts a force on other electric charges
- Charles Coulomb used a torsion balance in the 1780s to investigate the factors that affect the magnitude this force



- Coulomb reasoned that:
  - If a charged sphere is place in contact with an uncharged sphere, the charge is distributed equally between them
  - Induced charges presented some difficulty, but he was able to argue that the force was directly proportional to the charges
  - If the distance increased, the force decreased by the square of the distance

Coulomb's Law

$$F = k\frac{q_1 q_2}{r^2}$$

- k = 9x10^9 Nm^2/C^2
- q_1 and q_2 are the charges measured in coulombs (C)
- r is the distance between the charges (m)

Note

- Coulomb's law applies to objects whose size is much smaller than the distance between them
- In other words, they can be considered as point charges

Example

- A hydrogen atom has a proton at its center and an electron "orbiting" at a distance of 0.53x10^{-10} m. Determine the magnitude of the force on the electron.

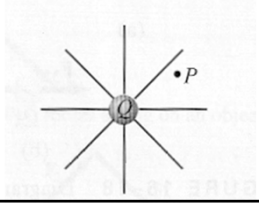
$$F = k\frac{q_1 q_2}{r^2}$$

$$F = (9\text{x}10^9\ \text{Nm/C}^2)\frac{(1.6\text{x}10^{-19}\ \text{C})(1.6\text{x}10^{-19}\ \text{C})}{(0.53\text{x}10^{-10}\ \text{m})^2}$$

$$F = 8.2\text{x}10^{-8}\ \text{N}$$

Electric Field

- The area around a charge or arrangement of charges is said to contain an electric field
- We can investigate the strength of the electric field by measuring the force on a small **positive** test charge



What's a test charge?

- A test charge is a charge that is so small that the force it exerts does not significantly alter the distribution of charges that create the field being measured

- We define the electric field as the force per unit charge experienced by a small positive test charge q:

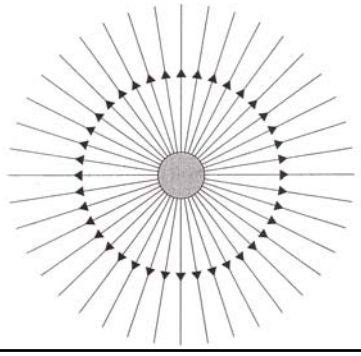
$$E = \frac{F}{q} \qquad \boxed{F = qE}$$

- Electric field is a vector
- The electric field points in the same direction as the force a positive charge would experience
- Measured in N/C

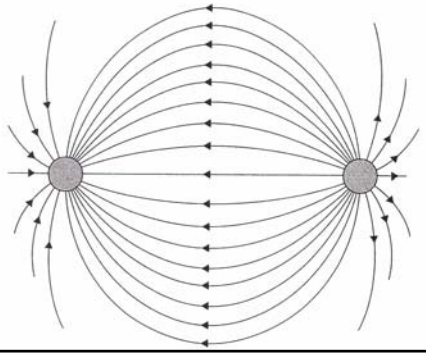
Electric Field Lines

- Electric field lines are imaginary lines (curved or straight) where the tangent to the field line at a point gives the direction of the electric field
- A single positive charge creates an electric field that is directed radially out of the charge, thus the electric field lines are straight lines coming radially out of the charge
- For a negative charge, the lines are directed into the charge

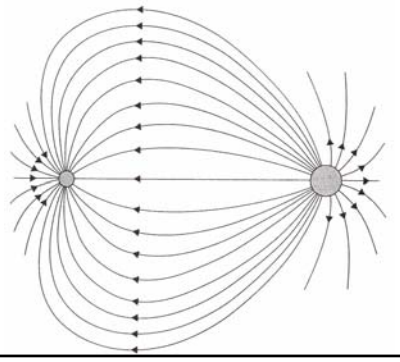
Single point or spherical charge



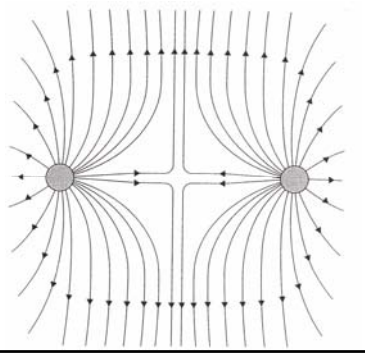
Two equal and opposite charges



Two opposite and unequal charges



Two equal positive charges



Uniform Field

- A uniform field is one that has constant magnitude and direction
- Such a field is generated between two oppositely charged parallel plates
- Near the edges of the plates the field lines are curved, indicating the field is no longer uniform there
- This **edge effect** is minimized when the length of the plates is long compared with their separation

Two long parallel charged plates