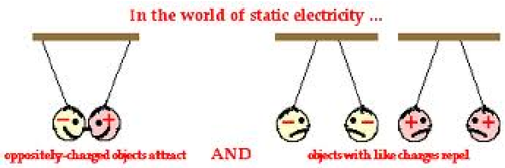
10.2 - Electric Force



Electric Force

<u>Coulomb's Law</u>: Electric force between two charges:

$\lvert F_E \rvert = k \left\lvert \frac{q_1 q_2}{r^2} \right\rvert$ AP Equation	k = 9.0 E 9 N·m^2/C^2 (Coulomb's Law Constant) q_1 and q_2 = charges (C) r = charge separation (m).

This equation yields force, not direction.

Since charge can be positive or negative, force has a positive or negative sign which indicates direction.

Positive = repulsive force, negative is attractive.

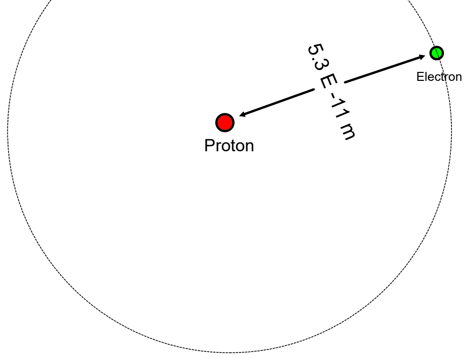
Electric Force Details

Electric force is a <u>field force</u>, like gravity, where contact is not necessary.

Big difference: gravity is attractive, while electric force is repulsive **or** attractive.

1. Hydrogen Example:

In hydrogen, the electron and proton are separated by 5.3 E -11 meters. Find the electric force: the charges are – 1.6 E -19 C and + 1.6 E -19 C.



Hydrogen Answer

Setup: $F_E = k\frac{q_1 q_2}{r^2}$

$$F_E = 9.0E9\frac{N \bullet m^2}{C^2} \bullet \frac{(-1.6E-19C)(1.6E-19C)}{(5.3E-11m)^2} = -8.2E-8N$$

The negative sign indicates an attractive force between the particles.

Ratio Examples

2. Consider two positive charges. How would the force between them change if one were doubled?

$F_E = k\frac{q_1 q_2}{r^2} \rightarrow k\frac{2q_1 \bullet q_2}{r^2}$ The force doubles.

3. How would the force change if one were tripled, and the other halved?

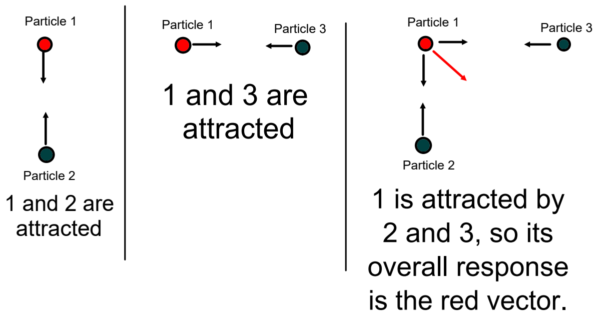
$F_E = k\frac{q_1 q_2}{r^2} \rightarrow k\frac{3q_1 \bullet \frac{1}{2}q_2}{r^2}$ The force increases by a factor of 1.5.

4. If both charges double, and the radius triples?

$F_E = k\frac{q_1 q_2}{r^2} \rightarrow k\frac{2q_1 \bullet 2q_2}{(3r)^2}$ The force diminishes by a factor of 4/9.

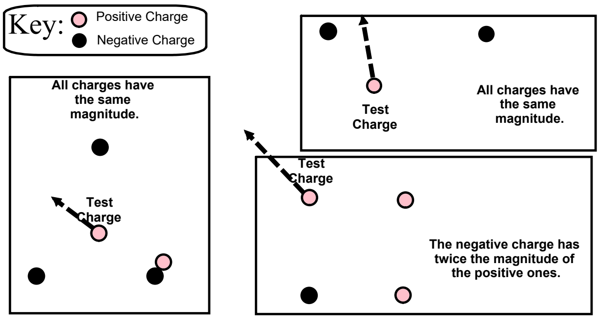
Superposition

With several charges, the net force equals vector sum of the individual forces.



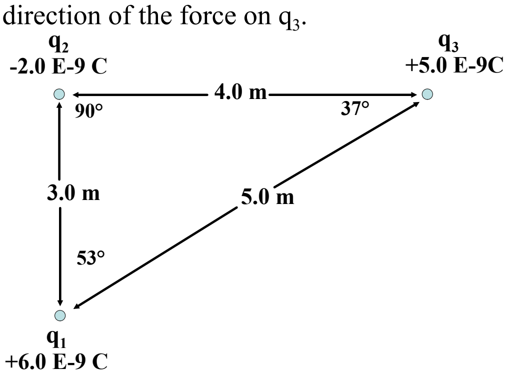
4. Conceptual Force Vectors

For the following configurations, what is the resulting force on the test charge?



5. Superposition Example:

For the following system, find the magnitude and direction of the force on q_3.



Superposition Answer 1

Calculate forces for both pairs of charges:

$$F_{q_1-q_3} = k\frac{q_1 q_3}{r^2}$$

$$= 9.0E9\frac{N\bullet m^2}{C^2}\bullet\frac{(+6.0E-9C)(+5.0E-9C)}{(5.0m)^2}$$

$$= +1.1E-8N \quad \text{(Repulsive force)}$$

$$F_{q_2-q_3} = k\frac{q_2 q_3}{r^2}$$

$$= 9.0E9\frac{N\bullet m^2}{C^2}\bullet\frac{(-2.0E-9C)(+5.0E-9C)}{(4.0m)^2}$$

$$= -5.6E-9N \quad \text{(Attractive force)}$$

Superposition Answer 2

Vector sum:

1. Decompose: F_{q1-q3} = + 1.1 E -8 N at 37°.
   x-component: $F_{E_x} = F\cos\theta = 1.1E-8N\bullet\cos 37^\circ = 8.8E-9N$
   y-component $F_{E_y} = F\sin\theta = 1.1E-8N\bullet\sin 37^\circ = 6.6E-9N$

F_{q2-q3} has only an x-component of -5.6 E -9 N.

2. Add x and y components separately:
   X-component: 3.2 E -9 N
   Y-component: 6.6 E -9 N

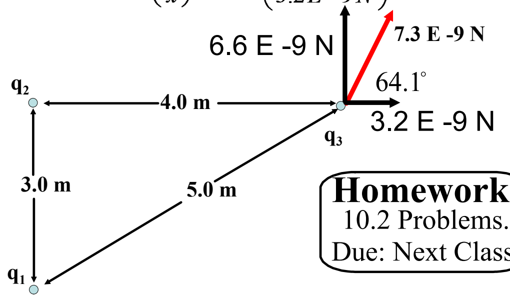
Superposition Answer 3

Magnitude:

$$F = \sqrt{x^2+y^2} = \sqrt{(3.2E-9N)^2+(6.6E-9N)^2} = 7.3E-9N$$

Direction:

$$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{6.6E-9N}{3.2E-9N}\right) = 64.1^\circ$$



Homework
10.2 Problems.
Due: Next Class.