Coulombs Law

Forces on Charges

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Forces Caused By Charges

- Two types of charges: positive and negative
- Charges exert forces on other charges over a distance
- Like charges repel
- Opposite charges attract
- Charged objects are always attracted to neutral objects

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Coulomb's Law

- Magnitude of the force that a tiny sphere with charge q_1 exerts on a second sphere with a charge of q_2, separated by a distance, d, is

$$F = K\frac{q_1 q_2}{d^2}$$

$K = 9.0 \times 10^9\ N \cdot m^2/C^2$

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Coulomb's Law

- Direction of Forces
  - Positive force symbolizes a repulsive force
  - Negative force symbolizes an attractive force
- Charged objects are always attracted to neutral objects
- Charge and force have a direct relationship.
- Distance and force have an inverse square relationship

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Coulomb's Law Example

- The electron and proton of a hydrogen atom are separated by an average distance of 5.3×10^{-11}m. Find the magnitude and direction of the electric force they exert on each other.

$$F = \frac{Kq_1q_2}{d^2} = \frac{(9 \times 10^{9})(+1.6 \times 10^{-19})(-1.6 \times 10^{-19})}{(5.3 \times 10^{-11} m)^2}$$

$$= -8.2 \times 10^{-8} N$$

ATTRACTIVE

Coulomb's Law Example

From the Problem:

$d = 5.3 \times 10^{-11}$ m

$$F = K\frac{q_1 q_2}{d^2}$$

From the Book:

$K = 9.0 \times 10^{9}$ N·m^2/C^2

$q_1 = -1.60 \times 10^{-19}$ C

$q_2 = +1.60 \times 10^{-19}$ C

$F = -8.2 \times 10^{-8}$ N, (-) indicates an attractive force

Sample Problem #2

- A 3.4 µC charge and a -5.2 µC charge experience a 0.23 N attractive force between each other. How far are the two charges apart from one another?

$F = K\frac{q_1 q_2}{d^2} \Rightarrow -.23 = \frac{(9\times10^9)(3.4\times10^{-6})(-5.2\times10^{-6})}{d^2}$

$-.23 = \frac{-.15912}{d^2} \Rightarrow d^2 = \frac{-.15912}{-.23}$

$d^2 = .692 \Rightarrow d = .83\,m$

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What happens when….

$F = (1)\frac{(1)(1)}{(1)^2} = 1$

- Double the one of the charges? $F = (1)\frac{(2)(1)}{(1)^2} = 2 \Rightarrow$ 2x LARGER
- Double one charge and triple the other? $F = (1)\frac{(3)(2)}{(1)^2} = 6 \Rightarrow$ 6x LARGER
- Double the distance between them? $F = (1)\frac{(1)(1)}{(2)^2} = \frac{1}{4} \Rightarrow$ 1/4 SMALLER
- Double one charge, quadruple the other and double the distance? $F = (1)\frac{(2)(4)}{(2)^2} = \frac{8}{4} = 2 \Rightarrow$ 2x LARGER

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What if..

- Two charges have a force of 13 N between them and you double the amount of one of the charges. What is the new force?

  $F = (1)\frac{(1)(2)}{(1)^2} = 2 \Rightarrow 2\times$ LARGER $= 2(13) = 26\,N$

- Two charges are 20 cm apart and they have a force of 24 N between them. Spreading them to 40 cm, what is the new force?

  DOUBLE DISTANCE

  $F = (1)\frac{(1)(1)}{(2)^2} = \frac{1}{4} = \frac{1}{4}$ SMALLER $= \frac{1}{4}(24) = 6\,N$

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