Coulomb's Law

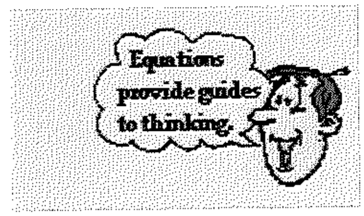
Read from **Lesson 3** of the **Static Electricity chapter** at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/estatics/u8l3b.html
http://www.physicsclassroom.com/Class/estatics/u8l3c.html
http://www.physicsclassroom.com/Class/estatics/u8l3d.html

MOP Connection: Static Electricity: sublevels 8 and 9

Coulomb's Law can be states in equation form as

$$F = \frac{k\,Q_1\,Q_2}{d^2}$$



This equation can be used as an *algebraic recipe* for solving computational problems or as a *guide to thinking* about how an alteration in the quantity of charge or the distance between charged objects effects the amount of attractive or repulsive force.

Using Coulomb's Law as a "Guide to Thinking"

Alteration in the Quantity of Charge

0.16 1. Two charged objects have a repulsive force of .080 N. If the charge of one of the objects is doubled, then what is the new force? x2 · .08 = 0.16

0.32 2. Two charged objects have a repulsive force of .080 N. If the charge of both of the objects is doubled, then what is the new force? 0.08 x4 = 0.32

Alteration in the Distance between Charged Objects

0.02N 3. Two charged objects have a repulsive force of .080 N. If the distance separating the objects is doubled, then what is the new force? $d^2 \times 2^2 = 4$ .08/4 = 0.02N

0.0088 4. Two charged objects have a repulsive force of .080 N. If the distance separating the objects is tripled, then what is the new force? $d^2 = 3^2 = \frac{1}{9}$ $.08 \cdot \frac{1}{9} = .0088N$

.005N 5. Two charged objects have an attractive force of .080 N. If the distance separating the objects is quadrupled, then what is the new force? $\frac{1}{4^2} = \frac{1}{16}$ $.08 \cdot \frac{1}{16} = 0.005N$

0.02 6. Two charged objects have a repulsive force of .080 N. If the distance separating the objects is halved, then what is the new force? $.08 \cdot \frac{1}{4} = 0.02$

Alteration in both the Quantity of Charge and the Distance

0.04N 7. Two charged objects have a repulsive force of .080 N. If the charge of one of the objects is doubled, and the distance separating the objects is doubled, then what is the new force? $.08 \times 2 = 0.16 \cdot \frac{1}{4} = 0.04N$

0.08N 8. Two charged objects have a repulsive force of .080 N. If the charge of both of the objects is doubled and the distance separating the objects is doubled, then what is the new force? $.08 \cdot \times 2 \cdot \times 2 = 0.32 \cdot \frac{1}{4} = .08N$

0.08N 9. Two charged objects have an attractive force of .080 N. If the charge of one of the objects is increased by a factor of four, and the distance separating the objects is doubled, then what is the new force? $.08 \cdot 4 \cdot \frac{1}{2^2} = 0.08$

0.026N 10. Two charged objects have an attractive force of .080 N. If the charge of one of the objects is tripled and the distance separating the objects is tripled, then what is the new force? $.08 \times 3 \times \frac{1}{3^2} = 0.026N$

Using Coulomb's Law as an "Algebraic Recipe" $K_e = 9.0E9\ N\,m^2/C$

11. A balloon with a charge of 4.0×10^{-5} C is held a distance of 0.10 m from a second balloon having the same charge. Calculate the magnitude of the repulsive force. **PSYW**

$$F = \frac{kQq}{d^2} = \frac{9.0E9\,(4.0E-5)(4.0E-5)}{.10m^2} = 1440\ N$$

12. Calculate the electrical force (in Newtons) exerted between a 22-gram balloon with a charge of -2.6 μC and a wool sweater with a charge of +3.8 μC; the separation distance is 0.75 m. (NOTE: a μC or microCoulomb is a unit of charge; $10^6\ \mu C = 1\ C$) **PSYW**

$$\frac{(9.0E9)\,2.6E-6C \cdot 3.8E-6C}{(0.75)^2} = 1.58E-19N$$

13. Suppose that two equally charged spheres attract each other with a force of -0.492 N ("-" means attractive) when placed a distance of 29.1 cm from each other. Determine the charge of the spheres. **PSYW**

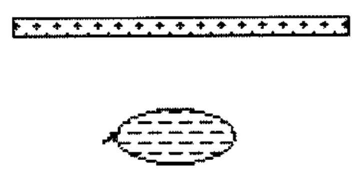
$$0.492N = \frac{Kq^2}{(0.291\,m)^2} \qquad F = \frac{Kqq}{d^2} \qquad \sqrt{\frac{Fd^2}{K}} = \sqrt{\frac{0.492 \cdot (0.291)^2}{9.0E9}}$$

$$q = 2.15E-6C$$

14. A +5.0 μC charge and a -6.0 μC charge experience an attractive force of -0.72 N ("-" means attractive). Determine their separation distance. **PSYW**

$$F_{0.72} = \frac{9.0E9 \cdot 5E-6C \cdot 6E-6C}{d^2} \qquad d = 0.61m\ (61cm)$$

15. A balloon has been rubbed with wool to give it a charge of -1.0×10^{-6} C. A plastic tube with a charge of $+4.0 \times 10^{-6}$ C is held a distance of 0.50 m above the balloon. Determine the electrical force of attraction between the tube and the balloon. **PSYW**



$$\frac{(9.0E9)\,1.0E-6\,(4E-6)}{(0.5)^2} = 0.144N$$

In the space at the right, construct a free-body diagram showing the direction and the type of all forces acting upon the 30.0-gram balloon.

Will the balloon accelerate up, down, or not at all? ____________

If there is an acceleration, then calculate its value. (Assume that the plastic tube is held a constant distance of 0.5 m from the balloon.) **PSYW**

$$F_w = ma_g \rightarrow 0.03kg \cdot 10 = .3N \downarrow$$

$$F_{net} = 0.144 - 0.3N = -.156N \text{ down} \downarrow$$

$$F_{net} = ma \quad \frac{0.156}{.03kg} = 5.2m/s \downarrow$$