Electrostatics

The three particles which make up almost all detectable matter in the universe are the proton, the electron, and the neutron. The proton has a charge of $+1.6 \times 10^{-19}$C, the electron has a charge of -1.6×10^{-19}C, and the neutron has zero charge. The unit for charge is the Coulomb, C.

Answer Webassign Question 1

Most objects have approximately the same number of electrons as protons, making them neutral. If an object has more electrons than protons, it is negative, fewer electrons than protons, positive.

Objects in which charge can move freely are called *conductors* and objects in which charges cannot are called *insulators*. For metal conductors, it is the negative electrons that are free to move in a grid of positive nuclei.

Like mass, charge is conserved in a closed system, so the total charge you begin with is what you end with.

Charged particles and charged objects interact with each other, similar charges repelling each other and opposite charges attracting each other. The law by which they do this is called Coulomb's law.

$$F_{electrostatic} = \frac{k \cdot q_1 \cdot q_2}{R^2}$$

k is a constant, $9.0 \times 10^9 \frac{N \cdot m^2}{C^2}$

q_1 and q_2 are the two interacting charges

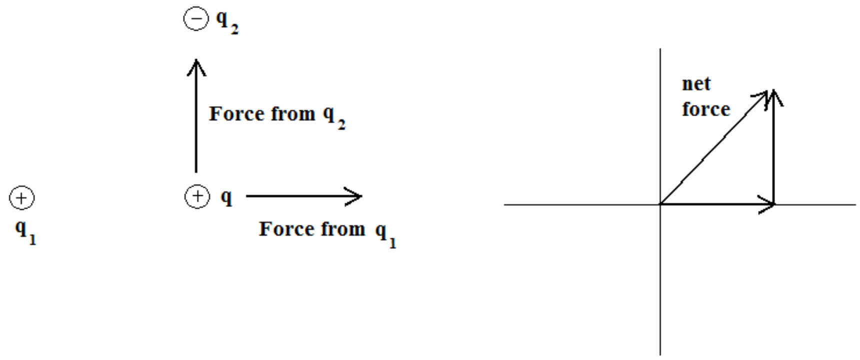
R is the distance between the charges or the distance between the centers of the charged objects, assuming radial symmetry of charge distribution

Answer Webassign Question 2

Answer Webassign Question 3

This equation is very similar to the equation for universal gravity. Two key differences are the magnitude of the leading coefficient (9.0×10^9 versus 6.67×10^{-11}) and the fact that gravity is always an attractive force while the electrostatic force can be attractive or repulsive.

As with all forces, this is a vector equation, meaning many different charges can act on a single charge and the net force would be the vector sum of all of the individual forces.

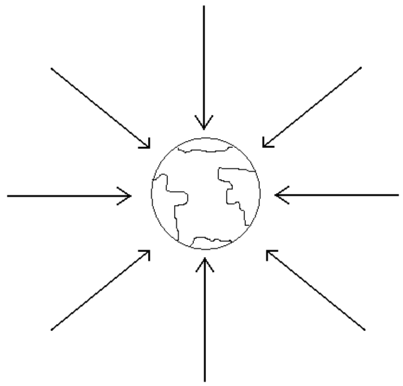


Answer Webassign Question 4

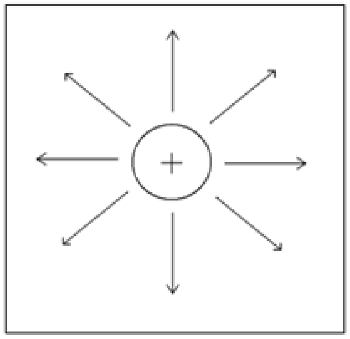
This electrostatic force underlies many mechanical forces. When two surfaces are pushed into each other, it is the electrostatic repulsion between their charges that creates the force that they push back with. When a spring is stretched or compressed, the charged particles making-up the spring are displaced from their molecular equilibrium, creating the spring force. The tension in a cord or rope has a similar origin.

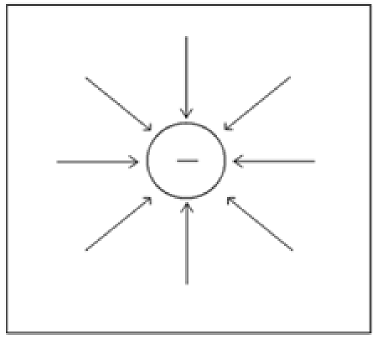
Also, the same way a planet with mass can create a gravitational field which surrounds the planet, a charge creates an electric field around itself.

The gravitational field of a planet is defined by how a mass in the vicinity would be experience a force, thus all field lines point in towards the planet. This is also known as a vector field.



Likewise, the electric field is defined by a how a small positive charge would experience a force if placed somewhere in space. If placed near a large positive charge, it would be repelled. If placed near a large negative charge, it would be attracted.





If we define electric field (**E**) as electric force per charge, then for a point charge creating a field:

$$\mathbf{E} = \frac{\boldsymbol{F}}{q}$$

$$\mathbf{E} = \frac{\frac{k \cdot Q \cdot q}{R^2}}{q} = \frac{k \cdot Q}{R^2}$$

For example, the electric field one centimeter from a proton would be:

$$\mathbf{E} = \frac{(9\ x\ 10^9)\cdot(1.6\ x\ 10^{-19})}{0.01^2} = 1.44 \text{ x } 10^{-5}\ \frac{N}{C}$$

Answer Webassign Question 5