***Coulomb’s Law:***

Charged objects exert forces on one another. This is very similar to what happens with gravity between two objects that have mass. Recall that Newton’s universal law of gravity can be used to calculate the force between two objects that have mass. It turns out that there is a similar law that can be used to calculate the force between two objects that have charge.

This law is called ***Coulomb’s law***. Here it is:



***F*** is the force exerted between the two charges. ***q1*** and ***q2*** are the two charges. (Note, we will actually use the absolute value of the charges - we simply don’t care about whether they are positive or negative.) ***r*** is the distance between the two charges andis called Coulomb’s Constant. It is similar to the universal gravitational constant.

The value for Coulomb’s constant is:



Coulomb’s law in most physics books is usually written in a slightly different form:



The force between two charged objects can be either attractive or repulsive, depending on whether the charges are like or unlike.

We will also assume that the charges are concentrated into a small area – ***point charges***.

***Electric Force and Gravity:***

Both gravity and the electric force are fundamental forces.

The equations for the gravity and the electromagnetic force have the same form; they are both inverse square relationships.

 and

Where the  term is the constant for Coulomb’s law and ***G*** is the constant for the law of gravity.

**There are four really significant differences in the two forces**:

* Gravity is always attractive. The electromagnetic force can be either attractive or repulsive.
* Gravity is much weaker.
* Gravity has a much greater range within which it is a significant force.
* The electric force can be shielded, blocked, or cancelled. You cannot do any of these things with the gravity force.

***The force of gravity is around 1040 times smaller than the electromagnetic force***.

This can be seen in a comparison of the two proportionality constants.

 = 8.99 x 109 Nm2/C2 for the electric force

***G*** = 6.67 x 10-11 Nm2/kg2 for the gravitational force

***The two constants differ by a factor of 1020!***

***Gravity extends out to great distances***. The sun is 92 million miles away from the earth, yet the force of gravity is large enough to cause the earth to be locked in an orbit around the sun. ***Now for electricity, the force between two charges drops off very quickly with distance***. This is because the magnitude of the two charges is very small – at the most, maybe a few Coulombs. But with gravity, we are dealing with enormous masses - the mass of the sun is 1.99 x 1030 kg! Because of these large masses, even though the gravity constant is very small, the force of gravity between really large masses ends up being a really big force that reaches out over distances of billions and even trillions of kilometers.

Let us compare forces in a hydrogen atom. The hydrogen atom is made up of a proton and an electron. The two particles attract each other because they both have mass and they also have opposite charges.

The magnitude of the electron/proton charge is 1.60 x 10-19 C. The distance between them in a hydrogen atom is around 5.3 x 10-11 m. For the mass of an electron we’ll use 9.1 x 10 –31 kg. For the mass of a proton we’ll use 1.7 x 10 –27 kg.

1. Find the force of gravity between the two electrons:
2. Find the electromagnetic force between the objects

**Answers:**

1. Find the force of gravity between the two electrons:



 (Pretty small, ain’t it?)

1. Find the electromagnetic force between the objects





Looking at the two forces, we see that gravity is much weaker. The electromagnetic force is 2.2 x 1039 times bigger!

***Gravity vs. Electromagnetic Force:*** Gravity fields and electric fields are both similar and different at the same time. Here is a handy little table to organize things:

Gravity Force Electromagnetic Force

Attracts attracts and repels

inverse square law inverse square law

surround objects surround objects

cannot be shielded can be shielded

incredibly weaker enormously stronger