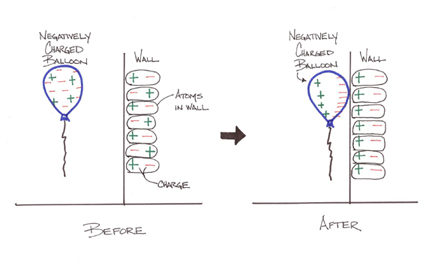
**Gravitational vs. Electromagnetic Activity**

**Introduction**

There are four forces known in nature: gravitational force, electromagnetic force, strong nuclear force and weak nuclear force. For our purposes we will only be looking at the first two forces. The gravitational force is a function of the mass of two objects. It is an attractive force and has an infinite range. It is the force that holds us on the Earth.

Electromagnetic force, on the other hand, is a function of the charge or magnetic force between two objects. This force also has an infinite range, but unlike gravity, electromagnetic force can be attractive or repulsive. Objects get their strength, shape and hardness from this force.

Within electromagnetic force, this activity will focus on electrostatic forces. Electrostatic force is a function of the charges of two objects. The charges can include positive, negative and neutral in which the opposite charges attract and like charges repel each other. Each object contains charge but often the net charge is zero when the number of negative charges equals the number of positive charges. The charges are able to move though so when a balloon is rubbed against your hair, charge is transferred. As the balloon is put against a wall, the charges in the uncharged wall rearrange themselves due to the charged balloon and the balloon is attracted to the wall. This is called polarization. As the balloon is removed, the charges in the wall rearrange so that it is no longer charged.

In this activity you will be exploring gravitational and electrostatic forces by comparing their magnitudes in different situations.

**Procedures**

*Part A:*

1. Your group will be assigned either gravitational or electrostatic force. For the force you are assigned you will:

* Need to understand the force to be able to explain it to others
* Give examples of where this force can be observed
* Find the equation used to calculate this force and identify any constants used in that equation

1. An electron (e-1) and a proton (p+1) are 0.5 nm apart. Calculate the gravitational/electrostatic force (whichever you were assigned) for this situation.
2. Get together with a group studying the opposite force, explain the force you are assigned, and compare your results.

*Extension Activity:*

In your group, calculate the gravitational and electrostatic forces for two K+1 ions and for two Fr+1 ions. In both cases the two ions are 0.5 nm apart.

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| --- | --- | --- |
| **Helpful Numbers** | | |
| **Name** | **Symbol** | **Value** |
| Coulomb's Constant | k | 8.987x109 N m2/C2 |
| Gravitational Constant | G | 6.6x10-11 N m2/kg2 |
| mass of a proton | p+1 | 1.67 x 10-27 kg |
| Charge of a proton | Cp+1 | 1.6 x10-19 |
| Charge of an electron | Ce-1 | -1.6 x 10-19 |
| mass of an electron | me-1 | 9.11 x 10-31 kg |
| mass of a hydrogen ion | mH+1 | 1.67 x 10-27 kg |
| mass of a potassium ion | K+1 | 6.49 x 10-26 kg |
| mass of a francium ion | Fr+1 | 3.7018 x 10-25 kg |

**Questions to Consider**

1. What differences do you notice between the equations of the gravitational and electrostatic forces?
2. Do you notice any differences between the scales in which each force is commonly observed?
3. What difference do you notice between the magnitude of the gravitational and electrostatic forces in the proton/electron activity?
   1. Does this surprise you? Why or why not?
   2. Are the two forces attractive or repulsive? How do you know?
   3. Describe what you would expect to see in the magnitude of the two forces as the masses of the charged particles increase?
4. How do you think this activity relates to the nanoscale?

*Extension Activity Questions*

1. What trend do you notice between the magnitudes of the gravitational and electrostatic forces as the masses of the ions (p+1/e-1, K+1/K+1, and Fr+1/Fr+1) increase?
   1. Does this surprise you? Why or why not?

**Reference**

<http://www.nano-link.org/nano-infusion-project/nanoscience-fundamentals> (free registration before download)

<http://emandpplabs.nscee.edu/cool/temporary/doors/forces/fourforces.htm>

<http://phun.physics.virginia.edu/topics/electrostatics.html>

<https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_electricity/cub_electricity_lesson02_activity1.xml> (balloon picture)