Coulomb's Law Name _____

Part A: Coulomb's Law

$$F_E = k\frac{q_1 q_2}{r^2}$$

Symbol	**Quantity**	**SI Unit**
F_E	Electrostatic Force	Newtons
k	Coulomb's Constant 9.0×10^9 N m^2 / C^2	N m^2 / C^2
q_1	Charge 1	Coulombs (C)
q_2	Charge 2	Coulombs (C)
r	Distance between charges	Meters (m)

Charge	**Attractive or Repulsive?**
Positive and Positive	Repulsive
Negative and Negative	Repulsive
Positive and Negative	Attractive

Coulomb's Law Name _____

1. A charge of positive two coulombs is located 0.5 meters from a charge of positive three Coulombs. What is the force between them? Is the force attractive or repulsive?

Looking for	Formula	
Already Know		
Answer in a complete sentence *with unit*:		

2. A charge of positive three Coulombs is located 0.6 meters from a charge of negative four Coulombs. What is the force between them? Is the force attractive or repulsive?

Looking for	Formula	
Already Know		
Answer in a complete sentence *with unit*:		

3. Look back at your answers to **1.** and **2.** Do these look like large forces or small forces?

Coulomb:

- A Coulomb is the SI unit for charge.
- Coulombs are named for the French scientist Charles-Augustin de Coulomb, who discovered the relationship between charge and force.

- One Coulomb is a truly *massive* amount of charge! If a Coulomb of electrons is near another Coulomb, they will create a force of billions of Newtons!

6.24×10^{18} electrons have *one* Coulomb of charge.

Elementary Charge (e)

One electron has a charge of $-e$.
One proton has a charge of $+e$.
A neutron has a charge of 0.

One elementary charge is 1.602×10^{-19} Coulombs.

Angstrom

1×10^{-10} meters
The abbreviation for Angstroms is Å.
An angstrom is roughly the length scale of an atom.

4. Two electrons are separated by a distance of 3 angstrom. What is the force between them? Is that force attractive or repulsive?

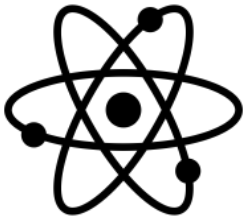
Looking for	Formula	
Already Know		
Answer in a complete sentence *with unit*:		

5. An electron is separated by a distance of 2 angstrom from a nucleus, which contains 3 protons and two neutrons. What is the force between them? Is that force attractive or repulsive?

Looking for	Formula	
Already Know		
Answer in a complete sentence *with unit*:		

6. An electron is separated by a distance of 12 angstrom from a nucleus, which contains 92 protons and 146 neutrons. What is the force between them? Is that force attractive or repulsive?

Looking for	Formula	
Already Know		
Answer in a complete sentence *with unit*:		

Angstrom	Aang Storm
	

Proportionality relationships in Coulomb's Law

Charge and Force Force and charge are *directly proportional* (if all other quantities are constant).
Distance and Force Force and distance have an *inverse square relationship* (if all other quantities are constant). Force is *inversely* proportional to the *square* of distance.

7. An electron has an attractive force of 20 microNewtons towards a nucleus.
What would be the force of three electrons towards this nucleus.

8. An electron has an attractive force of 40 microNewtons toward a nucleus. What would be the force of twenty electrons towards this nucleus?

9. An electron is 3 angstrom from a nucleus and has as an attractive force of 100 microNewtons. What would be the attractive force of an electron 12 angstrom from the nucleus?

10. An electron is 10 angstrom from a nucleus and has as an attractive force of 81 microNewtons. What would be the attractive force of an electron 30 angstrom from the nucleus?

11. An electron is 4 angstrom from a nucleus and has as an attractive force of 200 microNewtons. What would be the attractive force of an electron 2 angstrom from the nucleus?

12. An electron is 40 angstrom from a nucleus and has as an attractive force of 20 microNewtons. What would be the attractive force of an electron 10 angstrom from the nucleus?

13. An electron is 2 angstrom from a nucleus and has an attractive force of 30 microNewtons. What would be the attractive force of five electrons located 6 angstrom from the nucleus?

14. An electron is 6 angstrom from a nucleus and has an attractive force of 10 microNewtons. What would be the attractive force of ten electrons located 30 angstrom from the nucleus?

Gravitation and Electrostatic Force

Fundamental Forces

All of the forces in the universe come from four forces:
Gravitation, Electromagnetism, Strong Nuclear Force and Weak Nuclear Force

We deal with 1.25 of the fundamental forces in this class:

- Gravitation is described by "Newton's Law of Universal Gravitation"

- The *electrostatic Force*, described by Coulomb's Law, is one of four equations that make up the electromagnetic forces.

The big question: which is stronger in certain settings?

Which is stronger in the atomic setting?
There are two ways to answer this question, quantitatively or conceptually:

Quantitative Explanation:
Imagine two protons separated by a distance of 10 angstroms (1 nanometer).
The mass of a proton is 1.6726×10^{-27} kg.
The charge of a proton is the elementary charge of 1.602×10^{-19}.

Determine the magnitude of the electrostatic force between them:

Determine the magnitude of the gravitational force between them. Is this force attractive or repulsive?

Which force is stronger?

Which is stronger?
Is it a little bit stronger, one order of magnitude stronger, or many, many orders of magnitude stronger?

[Answer: the electrostatic force is many orders of magnitude stronger, which means gravity is negligible. It has no effect on the atomic world**.]

Conceptual Explanation:
Imagine two protons close together.
Is the electrostatic force attractive or repulsive?

Is the gravitational force attractive or repulsive?

What do the protons actually do (attract or repel)?

Therefore, which force must be stronger:

Gravity is Weak!

The gravitational force must be weaker than other forces, because it is *always attractive*, whereas other forces are sometimes attractive and sometimes repulsive.
If gravity were stronger than other forces, then nothing would ever repel, everything would attract, and the entire universe would be pulled together and collapse on itself.

All of the interesting things and life that we understand exist because there are both attractive and repulsive forces that matter.

** Some physicists in the field of quantum gravity are trying to figure out gravity's effect on the quantum world.