Correction to Syllabus

Dr. McCarthy’s help session is **3:10 - 5:00 PM**
on Thursday in: Trailer O-3 OR some other trailer!
Electrons in Atoms

A neutral atom has as many electrons (-) as protons (+)

The protons are at the center of the atom in the **nucleus**, along with the **neutrons** (which have no charge)

If an atom looses (or gains) an electron it becomes an **ion**.

Electricity frequently involves movement of electrons (not protons)

**Why?**

Because electrons are about 2000 times less massive than protons.

\[ m_p = 1833 \ m_e \]

So it is much harder to accelerate a proton (\(F = ma\))
Challenge Question

In a flame, Hydrogen burns, combining with Oxygen to make water.

\[ 2H_2 + O_2 \rightarrow 2H_2O \]

Take 2 minutes to write a response to this question:
**Why** does this reaction happen? Why do the H’s and O’s stick together?

Now, turn to the person next to you & share your answers.
Chemical Bonds....

....Are not real things.
Negative electrons are attracted to the positive nucleus...

“Opposites attract”....but how much?

C. Coulomb (1736-1806) found that this force is proportional to the amount of charge on each of the objects \((q_1, q_2)\) ....

...and is inversely proportional to distance between the charges \((r)\) squared.
Coulomb’s Law

The **magnitude** of the force ($F$) between two point charges ($q_1$ & $q_2$) is:

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

SI unit: newton, N

“$k$” is a constant which measures the strength of the force. ...The units of $k$ are __________

$$k = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$$

**This force** of electricity holds atoms together, binds them into molecules & causes chemical reactions.
Coulomb’s Law also makes current flow in electronics, lets batteries work and powers all electric cars and trains.

\[ F = k \frac{|q_1||q_2|}{r^2} \]

To use this equation, pick two charges \((q_1 \& q_2)\), as distance \(r\) from each other. \{You can ignore their sign (+ or -) for now.\} \(F\) gives you the strength of the force that each exerts on the other.

**Challenge Question:** If the distance between two charges is doubled, does the force on them change? How?
Force is a **vector**, so has magnitude and direction.

The *direction* of electric force is **along the line connecting the charges**.
Electricity vs. Gravity

The two forces that rule our everyday life are: **gravity** and **electricity**.

They are both “inverse square” forces. (Their strength decreases with the square of distance.)

But they have important differences:

Gravity depends on **mass**, while electricity depends on **charge**.

Gravity always attracts; electricity can repel.

For all charged particles, the **electric force** is much stronger.

We can compare these two forces by looking at a Hydrogen atom:
One proton: $m_p = 1.67 \times 10^{-27}$ kg 

One electron: $m_e = 9.11 \times 10^{-31}$ kg

They are separated by a distance of: $r = 5.29 \times 10^{-11}$ m
Electricity vs. Gravity: H Atom

What is the Gravitational force between an electron and a proton?

\[ F_g = G \frac{M_1 M_2}{r^2} \]

\[ F_g = 6.67 \times 10^{-11} \text{Nm}^2 \text{kg}^{-2} \left( 9.11 \times 10^{-31} \text{kg} \right) \left( 1.67 \times 10^{-27} \text{kg} \right) / \left( 5.29 \times 10^{-11} \text{m} \right)^2 \]

\[ F_g = 3.63 \times 10^{-47} \text{N} \]

What is the \textbf{Electrical} force between an electron and a proton?

\[ F = k \frac{|q_1||q_2|}{r^2} \]

\[ F_e = (8.99 \times 10^9 \text{N m}^2/\text{C}^2) \left( 1.60 \times 10^{-19} \text{C} \right)^2 / \left( 5.29 \times 10^{-11} \text{m} \right)^2 \]

\[ = 8.22 \times 10^{-8} \text{N} \]
So, inside an atom, the electric force is....

\[ \frac{F_e}{F_g} = 2 \times 10^{39} \]

times stronger than gravity...!!
**Force Vectors**

Electric Charges Create Forces

Since **Force** is a *vector*, it has a **magnitude** and a **direction**.

It can also be expressed in terms of its components:

\[
F = F_x \hat{x} + F_y \hat{y}
\]

\[
F = [F_x, F_y]
\]