PHYS 1444 – Section 002
Lecture #2

Monday, Aug. 26, 2019
Dr. Jonathan Asaadi

- Brief history of physics
- Some basics
- Ch 21
  - Static Electricity and Charge Conservation
  - Charges in Atom, Insulators and Conductors & Induced Charge
  - Coulomb's Law
  - The Electric Field & Field Lines
  - Electric Fields and Conductors

Mo

Today's homework is homework #2, due 11pm, Tuesday, Sept. 3!!

Announcements

- 113/125 of you have registered in the homework system.
  - 88/113 submitted the homework!
  - Fantastic job!!
  - You need Dr. Yu's enrollment approval… So move quickly…
  - Remember, the deadline for the freebee homework is 11pm today, Monday, Aug. 26
  - You **MUST** submit the homework to obtain 100% credit!
- Reading assignment: CH21 – 7
- Quiz at the beginning of the class, Wed. Sept. 4
  - Appendix A1 – A8 and what we've learned this Wednesday
  - In class, this Wednesday, Sept. 4
  - You can bring your calculator but it must not have any relevant formula pre-input
    - No phone or computers can be used as a calculator!
  - BYOF: You may bring one 8.5x11.5 sheet (front and back) of **handwritten formulae** and values of constants for the exam
  - No derivations, word definitions, or solutions or setups of ANY problems!
  - No additional formulae or values of constants will be provided!
- No class next Monday, Sept. 2, Labor Day

Extra Credit Special Project #1

- Compare the Coulomb force to the Gravitational force in the following cases by expressing Coulomb force (F_C) in terms of the gravitational force (F_G)
  - Between two protons separated by 1m
  - Between two protons separated by an arbitrary distance R
  - Between two electrons separated by 1m
  - Between two electrons separated by an arbitrary distance R
- Five points each, totaling 20 points
- BE SURE to show all the details of your work, including all formulae, proper references to them and explanations
- Please staple them before the submission
- Due at the beginning of the class Wednesday, Sept. 4

Why do Physics?

Exp. {
- To understand nature through experimental observations and measurements (**Research**)

Theory {
- Establish limited number of fundamental laws, usually with mathematical expressions
- Predict the nature's course

⇒Theory and Experiment work hand-in-hand

⇒Discrepancies between experimental measurements and theory are good for improvements

⇒The general principles formulated through theory is used to improve our everyday lives, even though some laws can take a while till we see them amongst us

Brief History of Physics

- AD 18th century:
  - Newton's Classical Mechanics: A theory of mechanics based on observations and measurements
- AD 19th Century:
  - Electricity, Magnetism, and Thermodynamics
- Late AD 19th and early 20th century (Modern Physics Era)
  - Einstein's theory of relativity: Generalized theory of space, time, and energy (mechanics)
  - Quantum Mechanics: Theory of atomic phenomena
- Physics has come very far, very fast, and is still progressing, yet we've got a long way to go
  - What is matter made of?
  - How do matters get mass?
  - How and why do matters interact with each other?
  - How is universe created?

Models, Theories and Laws

- Models: An analogy or a mental image of a phenomena in terms of something we are familiar with
  - Thinking light as waves, behaving just like water waves
  - Often provide insights for new experiments and ideas
- Theories: More systematically improved version of models
  - Can provide quantitative predictions that are testable and more precise
- Laws: Certain concise but general statements about how nature behaves
  - Energy conservation law
  - The statement must be found experimentally valid to become a law
- Principles: Less general statements of how nature behaves
  - Has some level of arbitrariness

Uncertainties

- Physical measurements have limited precision, however good they are, due to:
  - Stat.{ – Number of measurements
  - Syst.{ – Quality of instruments (meter stick vs micro-meter)
    – Experience of the person doing measurements
    – Etc
- In many cases, uncertainties are more important and difficult to estimate than the central (or mean) values

Significant Figures

- Denote the precision of the measured values
  - The number 80 implies precision of +/- 1, between 79 and 81
    - If you are sure to +/-0.1, the number should be written 80.0
  - Significant figures: non-zero numbers or zeros that are not place-holders
    - 34, 34.2, 0.001, 34.100
      - 34 has two significant digits
      - 34.2 has 3
      - 0.001 has one because the 0's before 1 are place holders to position "."
      - 34.100 has 5, because the 0's after 1 indicates that the numbers in these digits are indeed 0's.
    - When there are many 0's, use scientific notation for simplicity:
      - $31400000=3.14\times10^{7}$
      - $0.00012=1.2\times10^{-4}$
    - How about 3000?
      - This book assumes all 0's are significant but it could be different in other cases!

Significant Figures

- Operational rules:
  - Addition or subtraction: Keep the **smallest number of decimal place** in the result, independent of the number of significant digits: 12.001+ 3.1= 15.1
  - Multiplication or Division: Keep the **smallest number of significant digits** in the result: 12.001 x 3.1 = 37, because the smallest significant figures is ?

What does this mean? **The worst precision determines the precision of the overall operation!!**

In English? **Can't get any better results than the worst measurement!**

SI Base Quantities and Units

Quantity	Unit	Unit Abbrevation
Length	Meter	m
Time	Second	s
Mass	Kilogram	kg
Electric current	Ampere	A
Temperature	Kelvin	k
Amount of substance	Mole	mol
Luminous Intensity	Candela	cd

• *There are prefixes that scales the units larger or smaller for convenience (see pg. 7)*

Prefixes, expressions and their meanings

Larger

- deca (da): 10^1
- hecto (h): 10^2
- kilo (k): 10^3
- mega (M): 10^6
- giga (G): 10^9
- tera (T): 10^{12}
- peta (P): 10^{15}
- exa (E): 10^{18}
- zetta (Z): 10^{21}
- yotta (Y): 10^{24}

Smaller

- deci (d): 10^{-1}
- centi (c): 10^{-2}
- milli (m): 10^{-3}
- micro (μ): 10^{-6}
- nano (n): 10^{-9}
- pico (p): 10^{-12}
- femto (f): 10^{-15}
- atto (a): 10^{-18}
- zepto (z): 10^{-21}
- yocto (y): 10^{-24}

How do we convert quantities from one unit to another?

Unit 1 = Conversion factor X Unit 2

1 inch	2.54	cm
1 inch	0.0254	m
1 inch	2.54×10^{-5}	km
1 ft	30.3	cm
1 ft	0.303	m
1 ft	3.03×10^{-4}	km
1 hr	60	minutes
1 hr	3600	seconds
And many	More	Here….

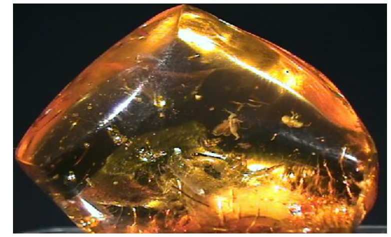
What does the Electric Force do?

- Electric force is the bases of modern technology
  - Virtually everything we use every day uses electric force
    - Can you give a few examples?

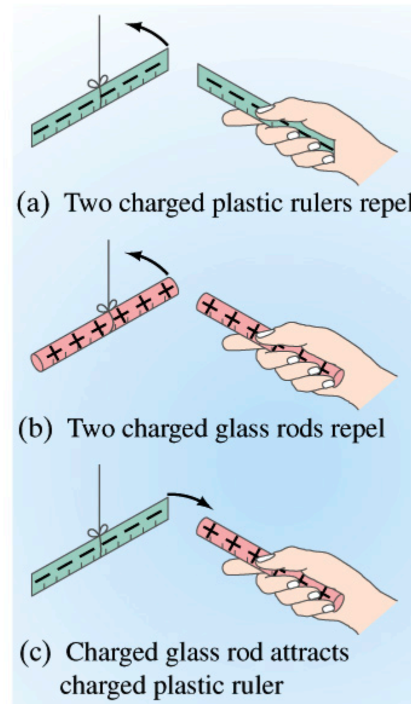
- But this force also affects many others
  - Making up materials with atoms and molecules
  - Biological metabolic processes
    - Nerve signals, heart pumping, etc
- Virtually all the forces we have learned in Physics I:
  - Friction, normal force, elastic force and other contact forces are the results of electric forces acting at the atomic level

Static Electricity; Electric Charge and Its Conservation

- Electricity is from Greek word *elecktron*=amber, a petrified tree resin that attracts matter if rubbed



- Static Electricity: an amber effect
  - An object becomes charged or "posses a net electric charge" due to rubbing
  - Can you give some examples?
- Two types of electric charge
  - Like charges repel while unlike charges attract
  - Benjamin Franklin referred the charge on glass rod as the positive, arbitrarily. Thus the charge that attracts glass rod is negative. ➔ This convention is still used.



(a) Two charged plastic rulers repel

(b) Two charged glass rods repel

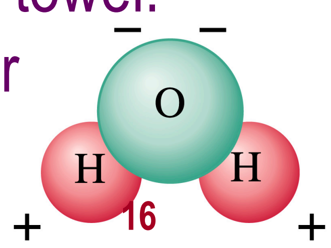
(c) Charged glass rod attracts charged plastic ruler

Static Electricity; Electric Charge and Its Conservation

- Franklin argued that when a certain amount of charge is produced on one body in a process, an equal amount of opposite type of charge is produced on another body.
  - The positive and negative are treated algebraically so that during any process the net change in the amount of produced charge is 0.
    - When you comb your hair with a plastic comb, the comb acquires a negative charge and the hair an equal amount of positive charge.
- This is the **law of conservation of electric charge.**
  - **The net amount of electric charge produced in any process is ZERO!!**
    - If one object or one region of space acquires a positive charge, then an equal amount of negative charge will be found in neighboring areas or objects.
    - No violations have ever been observed.
    - This conservation law is as firmly established as that of energy or momentum.

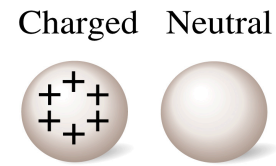
Electric Charge in an Atom

- It has been understood through the past century that an atom consists of
  - A positively charged heavy core ← What is the name?
    - This core is the nucleus and consists of neutrons and protons.
  - Many negatively charged light particles surround the core ← What is the name of these light particles?
    - These are called electrons
    - How many of these in an atom? **As many as the number of protons in the nucleus!!**
- So what is the net electrical charge of an atom?
  - Zero!!! Electrically neutral!!!
- Can you explain what happens when a comb is rubbed on a towel?
  - Electrons from the towel get transferred to the comb, making the comb negatively charged while leaving positive ions on the towel.
  - These charges eventually get neutralized primarily by water molecules in the air.

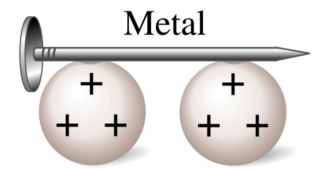


Insulators and Conductors

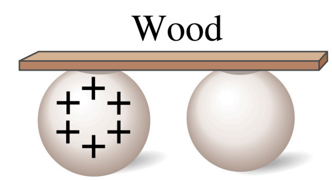
- Let's imagine two metal balls of which one is charged



- What will happen if they are connected by
  - A metallic object?
    - Some charge is transferred.
    - These objects are called <u>**conductors of electricity**</u>.
  - An wooden object?
    - No charge is transferred
    - These objects are called <u>**nonconductors or insulators**</u>.



(b) Conductor



(c) Insulator

- Metals are generally good conductors whereas most other materials are insulators.
  - There are third kind of materials called, semi-conductors, like silicon or germanium ➔ conduct only in certain conditions
- Atomically, conductors have loosely bound electrons while insulators have them tightly bound!