PHYS 1441 – Section 002
Lecture #2

Wednesday, Aug. 30, 2017

Dr. Jaehoon Yu

- Brief history of physics
- Some basics …
- Chapter 21
  - Static Electricity and Charge Conservation
  - Charges in Atom, Insulators and Conductors & Induced Charge
  - Coulomb's Law

Announcements

- 98/103 of you have registered in the homework system.
  - 79/98 submitted the homework!
  - Fantastic job!!
  - You need my enrollment approval… So move quickly…
  - Remember, the deadline for the first freebee homework is 11pm today, Wednesday, Aug. 30
  - You **MUST** submit the homework to obtain 100% credit!
  - Also please be sure to make the payment in time otherwise your access as well as my access to the site for grading is cut.
- Reading assignment: CH21 – 7
- Quiz at the beginning of the class, Wed. Sept. 6
  - Appendix A1 – A8 and what we've learned today!
- No class Monday, Sept. 4

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 the two protons separated by an arbitrary distance R
  - Between the two protons separated by 1m
  - Between the two electrons separated by an arbitrary distance R
  - Between the two electrons separated by 1m
- Five points each, totaling 20 points
- BE SURE to show all the details of your work and MUST list all formulae, the necessary parameters (mass of proton, electron, gravitational constant, Coulomb constant, etc) and compute the numbers as simple as possible
- Please staple them before the submission
- Due at the beginning of the class Wednesday, Sept. 6

In this course, you will learn…

- Concept of electricity and magnetism
- Electric charge and magnetic poles
- Electric and magnetic Forces
- Electric and magnetic potential and energies
- Propagation of electric and magnetic fields
- Relationship between the electro-magnetic force and light
- Behaviors of light and optics, the study of it
- Special relativity and quantum theories

How to study for this course?

- Keep up with the class for comprehensive understanding of materials
  - Come to the class and participate actively in the discussions and problems solving sessions
  - Follow through the lecture notes after each class
  - Work out example problems in the book yourself without looking at the solution
  - Have many tons of fun in the class!!!!!
- Keep up with the homework to put the last nail in the coffin
  - One can always input the answers as you solve problems. Do NOT wait till you are done with all the problems.
  - Form a study group and discuss how to solve problems with your friends, then work the problems out yourselves!
- Prepare for upcoming classes
  - Read the textbook for the material to be covered in the next class
- The extra mile
  - Work out additional end of chapter problems starting the easiest problems to harder ones

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:
      - $31400000 = 3.14 \times 10^{7}$
      - $0.00012 = 1.2 \times 10^{-4}$
    - 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….

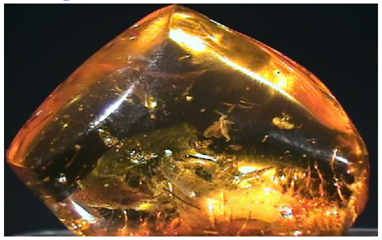
What does the Electric Force do?

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

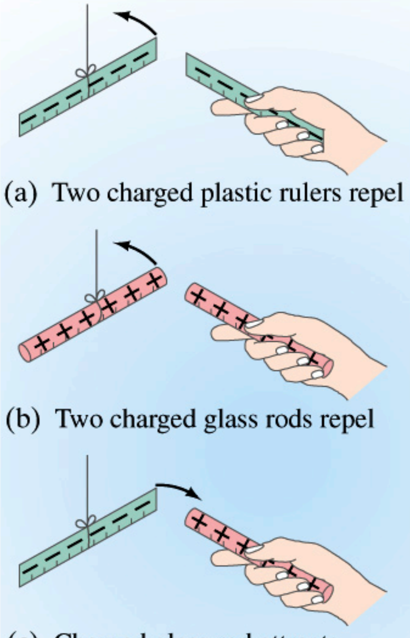
- But this force also affects many others
  - Making up materials with atoms and molecules
  - Biological metabolic processes
    - Nerve signals, heart pumping, etc
- Virtually all the forces we have learned in Physics I:
  - Friction, normal force, elastic force and other contact forces are the results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