PHYS 1441 – Section 002
Lecture #2

Monday, Aug. 31, 2020

Dr. Jaehoon Yu

- Brief history of physics
- Standards and units and other basics
- CH21
  - Static Electricity and Charge Conservation
  - Charges in Atom
  - Insulators and Conductors & Induced Charge
  - Coulomb's Law

Today's homework is homework #2, due 11pm, Wednesday, Sept. 9!!

Announcements

- Reading assignment: CH21 – 7
- 129/143 of you have registered in the homework system.
  - 115/129 submitted the homework!
  - Fantastic job!!
  - You need my enrollment approval. So move quickly.
  - Remember, the deadline for the first homework is 11pm, today, Monday, Aug. 31
  - 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.
- Quiz at the beginning of the class Wed., Sept. 2
  - Appendix A1 – A9 and what we've learned today (CH21 – 3 or 4?)!
  - BYOF: You may bring a one 8.5x11.5 sheet (front and back) of handwritten formulae and values of constants for the exam
  - No derivations, word definitions or setups or solutions of any problems!
  - No additional formulae or values of constants will be provided!
  - Must send me the photos of both front & back of the formula sheet, including the blank!
    - File name must be FS-Q1-LastName-FirstName-fall20.pdf

Basic Rules for Online Exams

- All quizzes and exams will be online on Quest, the same system as your online homework
- Academic integrity is very important to keep the system the fairest to all
  - We all have to work together to maintain the integrity!
- Leave the camera ON showing you and UNMUTE the mic at all times
- If you have questions, type into the zoom chat window to me
- POWER OFF your phone, iPADs and any other computing devices except for the computer you take exam with
- Quit all other applications and web pages, except zoom and the Quest
- Have your calculator, formula sheet and clean scrap sheets out
- Strongly suggest to write down the answers before entering
- Send me the photos of the front and back of your formula sheet no later than 1 hour prior to the exam (E)/quizzes (Q)
  - File name must be FS-Q1-LastName-FirstName-fall20.pdf

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 1m
  - Between the two protons separated by an arbitrary distance R
  - Between the two electrons separated by 1m
  - Between the two electrons separated by an arbitrary distance R
- Five points each, totaling 20 points
- BE SURE to show all the details of your own work, including all formulae, proper references to them and explanations
- Must be handwritten and submit all pages in a single PDF file
  - File name must be: SP1-LastName-FirstName-Fall20.pdf
- Due at the beginning of the class Wednesday, Sept. 9

What do we want to learn in this class?

- Physics is everywhere around you.
- Skills to understand the fundamental principles that surrounds you in everyday lives…
- Skills to identify what laws of physics applies to what phenomena and use them appropriately
- Understand the impact of physical laws and apply them
- Learn skills to think, research and analyze observations.
- Learn skills to express the observations and measurements in a mathematical language
- Learn skills to express your research in a systematic manner in writing
- But most importantly the confidence in your physics ability and to take on any challenges laid down in front of you!!

Even more importantly, let us have a lot of FUN!!

Specifically, in this course, you will learn…

- Concept of Electricity and Magnetism
- Electric charge and magnetic poles
- Electric and Magnetic Forces and fields
- Electric and magnetic potential and energies
- Propagation of electric and magnetic fields
- Relationship between electro-magnetic forces and light
- Behaviors of light and optics, the theory of light
- Special relativity and quantum theories

What can you expect from this class?

- All A's?
  - This would be really nice, wouldn't it?
  - But if it is too easy it is not fulfilling or meaningful….
- This class is not going to be a stroll in the park!!
- You will earn your grade in this class.
  - You will need to put in sufficient time and sincere efforts
  - Exams and quizzes will be tough!!
    - Sometimes problems might not look exactly like what you learned in the class
    - Do the work with your own hands!
- But you have a great control (up to 45%) of your grade in your hands
  - Homework is 25% of the total grade!!
    - Means you will have many homework problems
      - Sometimes much more than any other classes
      - Some homework problems will be something that you have yet to learn in class
      - Exam problems will be easier than homework problems but the same principles!!
  - Lab 10%
  - Extra credit 10%
- I will work with you so that your sincere efforts, despite COVID –19 related hardship are properly rewarded

How to study for this course?

- Keep up with the class for comprehensive understanding of materials
  - Come to the class and participate in the discussions and problems solving sessions
  - Follow through lecture notes
  - Work out example problems in the book yourself without looking at the solution
  - Have many tons of fun in the class, asking lots of questions!!!!!
- Keep up with the homework to put the last nail on 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 problems in the back of the book 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 until we see them amongst us

Brief History of Physics

- AD 17th and 18th century:
  - Newton's Classical Mechanics: A theory of mechanics based on observations and measurements
- AD 18th and 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 does matter get mass?
  - How and why do matters interact with each other?
  - How is the universe created?

Terminology: 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 that behave 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 (Poll 5)
  - Energy & momentum conservations, charge conservation, etc
  - 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 (Normally scales by $1/\sqrt{N}$)

Syst.{ – Quality of the 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 indicate that the numbers in these digits are indeed 0's.
    - When there are many 0's, use scientific notation for simplicity:
      - $31400000=3.14\text{x}10^{7}$ (on Quest 3.14E7 format is used)
      - $0.00012=1.2\text{x}10^{-4}$

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+ 3333.1= 3345.1
  - 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 than the worst of the measurements!**

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. 9)*
- *These simplifies the expression of numbers: 20,000,000,000 bytes ➔20GB*

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?

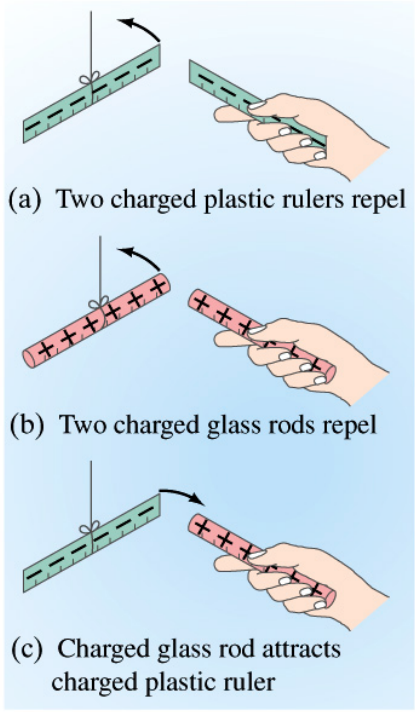
- Electric force is the bases of modern technology
  - Virtually everything we use every day uses the electric force
    - Can you give a few examples?

- But this force also affects much more
  - Making up materials with atoms and molecules
  - Biological and metabolic processes
    - Nerve signals, heart pumping, etc
- Virtually all contact 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 "possesses a net electric charge" due to rubbing
  - Can you give some examples?
- Two types of electric charge, positive/negative
  - 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.



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, it acquires the negative charge, and the hair gets 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 an 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 called the nucleus and consists of neutrons and protons.
  - Many negatively charged particles with small mass surround the core ← What is the name of these light particles?
    - These are called the 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?
  - The 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.