

PHYS 1444 – Section 002

Lecture #2

Monday, Jan. 27, 2020

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, Monday, Feb. 3!!

Announcements

- 73/88 of you have registered in the homework system.
 - 63/73 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, Jan. 27
 - You **MUST** submit the homework to obtain 100% credit!
- Reading assignment: CH21 – 7
- Quiz at the beginning of the class, Mon. Feb. 3
 - Appendix A1 – A8 and what we've learned this Wednesday
 - In class, next Monday, Feb. 3
 - 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!

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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, Feb. 5

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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: $12.001 \times 3.1 = 37$, 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 Abbreviation
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?

$$\text{Unit 1} = \text{Conversion factor} \times \text{Unit 2}$$

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....



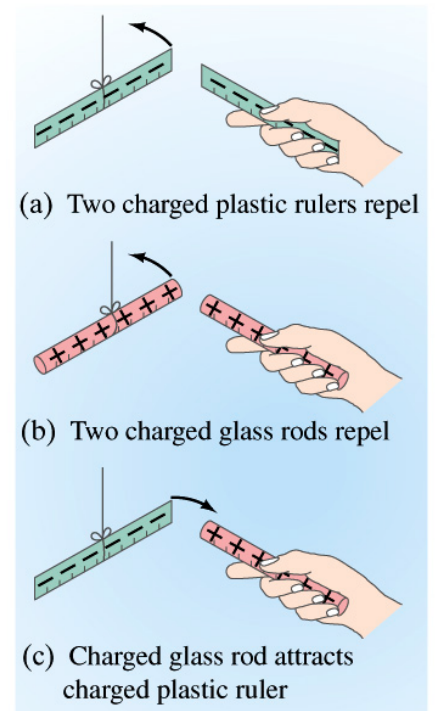
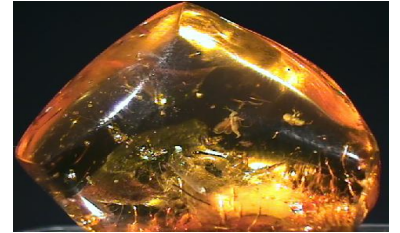
What does the Electric Force do?

- 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 *elektron*=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.



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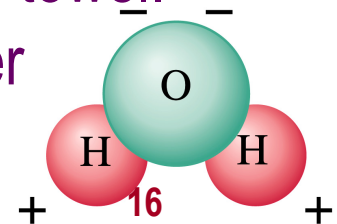
Static Electricity; Electric Charge and Its Conservation

- 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.



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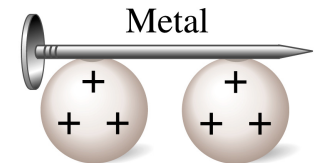
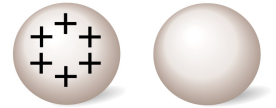


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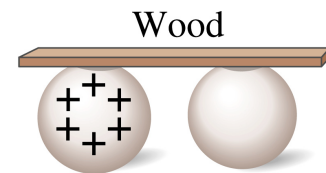
Insulators and Conductors

- 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 **conductors of electricity**.
 - An wooden object?
 - No charge is transferred
 - These objects are called **nonconductors or insulators**
- 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!

Charged Neutral



(b) Conductor



(c) Insulator