PHYS 1444 – Section 003
Lecture #1

Tuesday August 23, 2012

Dr. Andrew Brandt

1. Introduction (longish) and Syllabus
2. Chapter 21
   - -Static Electricity and Charge Conservation
   - -Charges in Atom, Insulators and Conductors
     &
     Induced Charge
3. Mastering Phys HW
   Due Tues. 28th

Please turn off electrical devices

Stow your tray tables and put seats back into the upright position

Thanks to Dr. Yu for bringing this class into 21st Century!

My Background+Research

B.S. Physics and Economics College of William&Mary 1985
PH.D. UCLA/CERN High Energy Physics 1992
(UA8 Experiment-discovered hard diffraction)

1992-1999 Post-doc and Lab Scientist at Fermi National Accelerator Laboratory
- -1997 Presidential Award for contributions to diffraction
- -Proposed and built (with collaborators from Brazil) DØ Forward Proton Detector
- -Physics Convenor
- -Trigger Meister

1999 Joined UTA as an Assistant Professor
2004 promoted to Associate Professor
2010 promoted to Full Professor

- Funding from NSF, DOE, and Texas approaching 10M$ as PI or Co-PI

My Main Research Interests

- High Energy Physics (aka Particle Physics)
- Physics with Forward Proton Detectors (detect protons scattered at small angles)
- Fast timing detectors (How fast? Really Really Fast!)
- Triggering (selecting the events to write to tape): at ATLAS must choose most interesting 300 out of up to 40,000,000 events/sec
- Higgs Discovery
- Weapons of Mass Destruction **(detection of)**

Primary Web Page

Course Specification for 1444 - 004, Fall 2011 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-hep.uta.edu/~brandta/teaching/fa2011/teaching.html

Most Visited Getting Started Voeckler Survives Tou... Latest Headlines

Course Specification for 1444 - 004, ...

Course Specification for 1444-004, Fall 2011

Class Schedule	17:30 - 18:50pm Mondays & Wednesdays Room 101, Science Hall
Instructor	Dr. Andrew Brandt
Office	Room 344, Chemistry and Physics Building Phone: (817) 272 - 2706 Secretary: (817) 272 - 2266
Office Hours	Mondays 4:00pm - 5:00pm, Tues 2:00 - 3:00; after class; or by appointment
Prerequisites	MATH 1426, PHYS 1443. You must enroll in a relevant lab section, unless exempt
Textbook	Physics for Scientists and Engineers, 4th Edition Douglas C. Giancoli (get version bundled with Mastering Physics) Prentice Hall

- Syllabus
- Lecture Notes
- Mastering Physics Homework Website Course ID: MPBRANDT1444FA11
- Link to Physics Labs

Return to Dr. Brandt's Home Page

Done

http://www-hep.uta.edu/~brandta/teaching/fa2012/teaching.html

Grading

- Homework: 20%
- Lab score: 20%
- Exams: 3*20%
  - Two midterms and one final
  - Comprehensive final
  - Exams will be curved if necessary
  - No makeup tests

Homework

- Solving homework problems is the best (only?) way to comprehend class material
- An electronic homework system has been setup
- Homework: will be done with Mastering Physics (can buy it with or without text book (costs more but worth it!)
- http://www.masteringphysics.com/
- Course ID: MPBRANDTFA2012
- First “assignment” due Tuesday Aug 28!!! It is meant to teach you how to use mastering physics
- 2Nd (first real assignment) due followingTuesday—11pm!

Mastering Physics Grades

- **For grading purposes, some numeric answers to questions need to be exact**. For example, the answer to the question "How many days are in a week?" must be **7**.
- **The typical grading tolerance for most numeric answers in Mastering assignment questions is between 2%-3%.** For example, if the grading tolerance is 2% and the correct answer is 1043, both 1042 or 1045 are also graded as correct.
- **When an answer is within tolerance, but doesn't match the correct answer:** The officially correct answer displays in a purple box (provided that Show Whether Answer is Correct is set to Always). Students should use this answer if subsequent parts of an assignment item require calculations based on this answer.
- **Students should use at least three digits or significant figures in answers**, unless otherwise specified or unless the exact answer can be expressed using fewer than three significant figures. If higher precision is required, or lower precision is allowed, this is specified in the question or its instructions. When students must do multiple calculations to get an answer they should use more significant figures than required during each calculation and round off at the end
- **You are allowed 6 attempts at a non multiple choice question (with each attempt you lose some points). If you get a wrong answer: reread problem, could you have made a sign error or a unit error or a round-off error?**

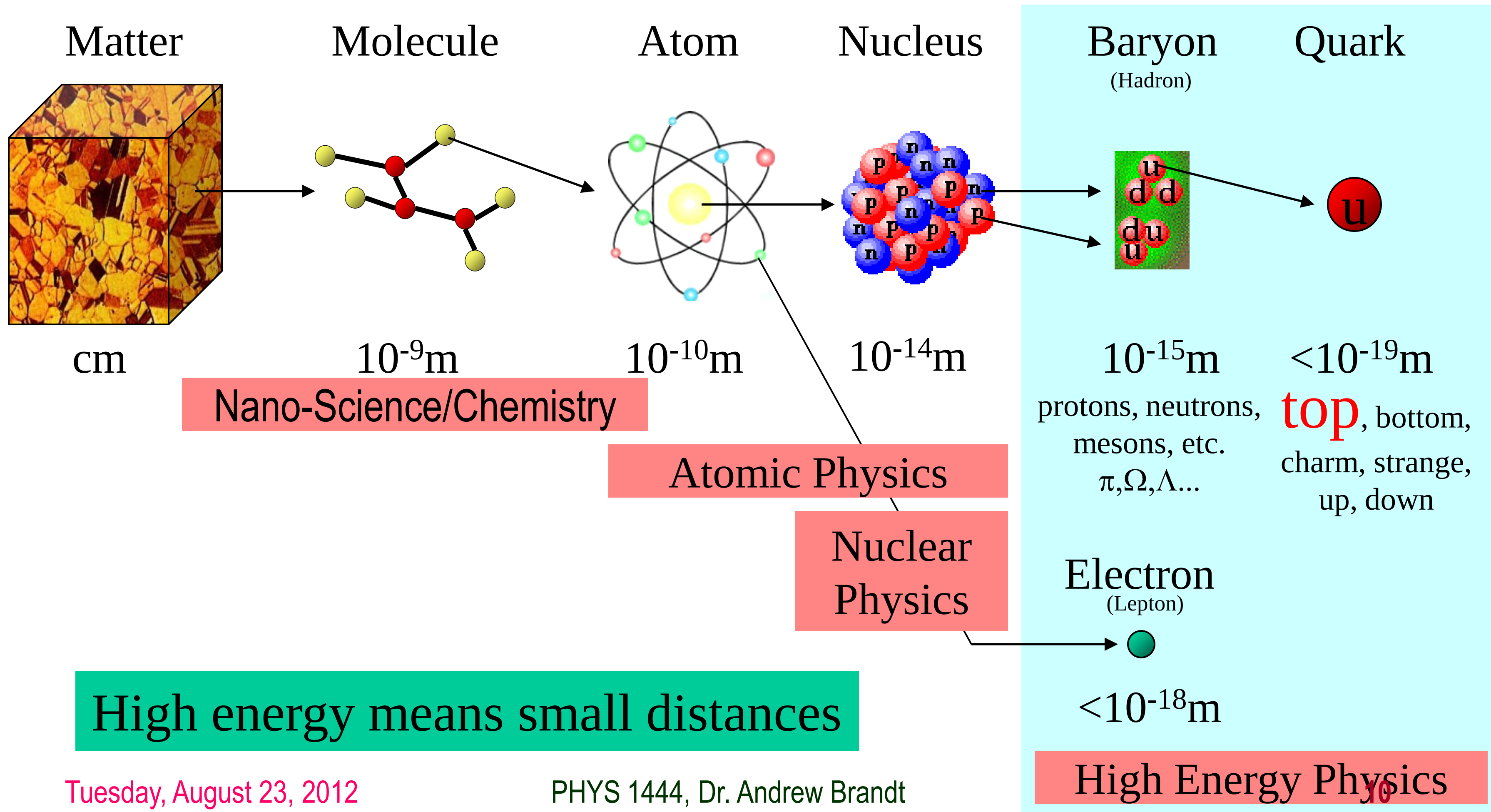
Attendance and Class Style

- Attendance:
  - is **STRONGLY** encouraged, but I will not take attendence (periodic pop quizzes for extra credit)
- Class style:
  - Lectures will be primarily on electronic media
    - The lecture notes will be posted **AFTER** each class
  - Will be mixed with traditional methods
  - Active participation through questions and discussion are encouraged (chances are someone else has the same question)

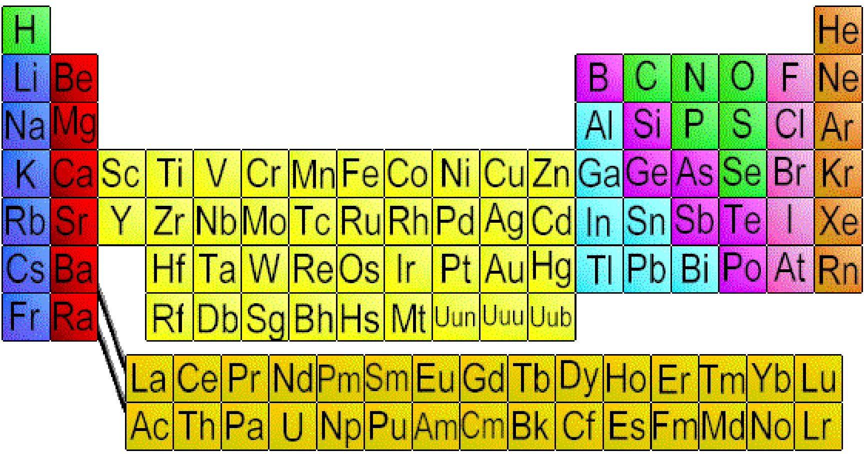
Brief History of Physics

- 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)
  - Discovery of electron
  - Einstein's theory of relativity: Generalized theory of space, time, and energy (mechanics)
  - Quantum Mechanics: Theory of atomic phenomena (small distance scales)
- Physics has come very far, very fast, and is still progressing, yet we've got a long way to go
  - Particle physics and astrophysics final frontier?

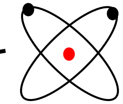
Structure of Matter



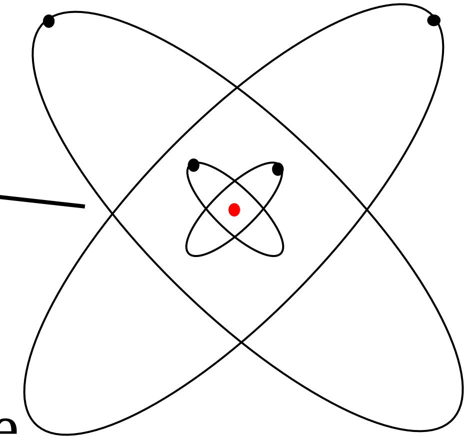
Periodic Table



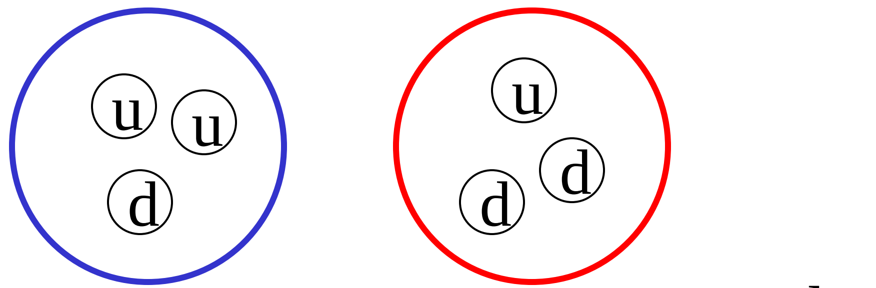
Helium



Neon



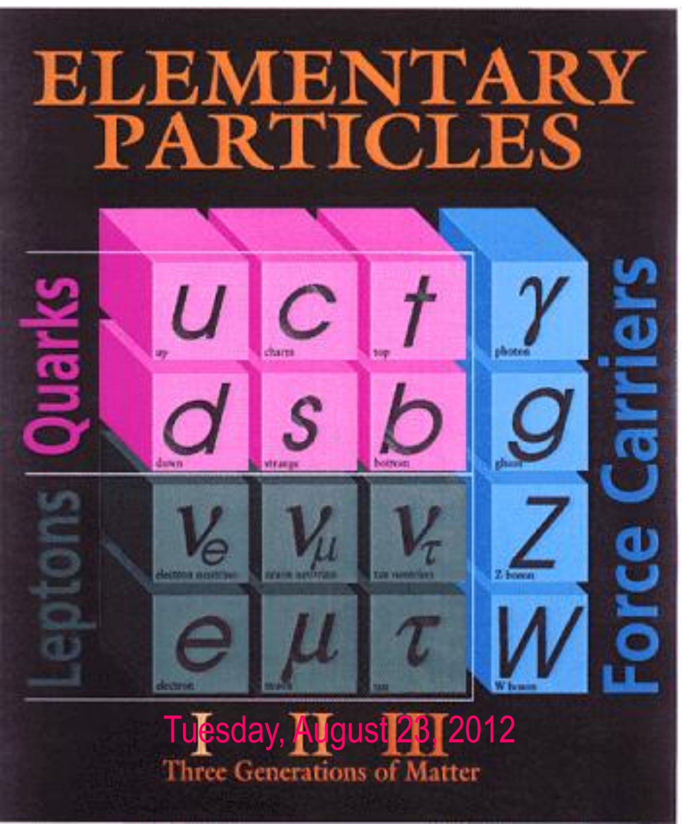
All atoms are made of protons, neutrons and electrons



Proton Neutron Electron

Gluons hold quarks together

Photons hold atoms together



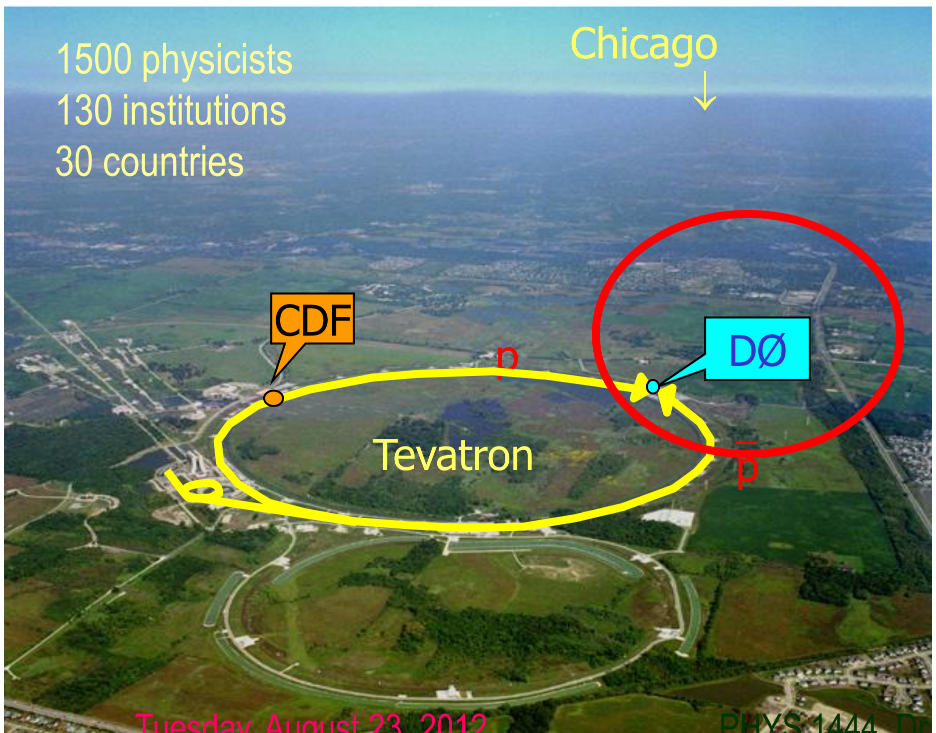
Role of Particle Accelerators

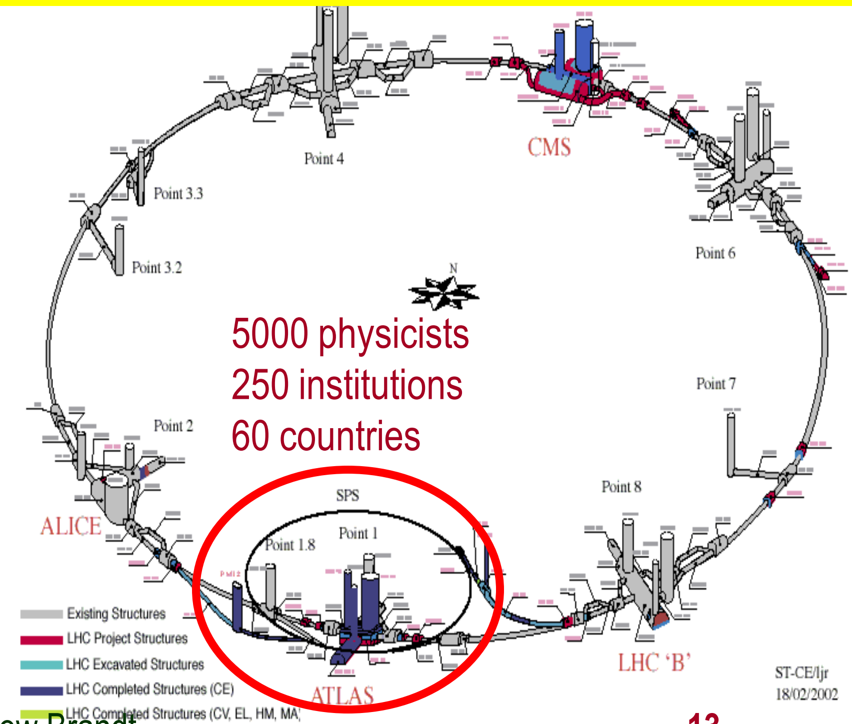
- Smash particles together
- Act as microscopes and time machines
  - The higher the energy, the smaller object to be seen
  - Particles that only existed at a time just after the Big Bang can be made
- Two method of accelerator based experiments:
  - Collider Experiments: protons, anti-protons, electrons, muons?
  - Fixed Target Experiments: Particles on a target
  - Type of accelerator depends on research goals

Fermilab Tevatron and CERN LHC

- Highest Energy proton-anti-proton collider
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p ➔ 13M Joules on $10^{-4}m^2$)
  - ⇒ Equivalent to the K.E. of a 20 ton truck at a speed 81 mi/hr

- Highest Energy (proton-proton) collider since fall 2009
  - E_{cm}=14 TeV (=44x10^{-7}J/p ➔ 1000M Joules on $10^{-4}m^2$)
  - ⇒ Equivalent to the K.E. of a 20 ton truck at a speed 711 mi/hr
  - ⇒ Currently 8TeV collisions

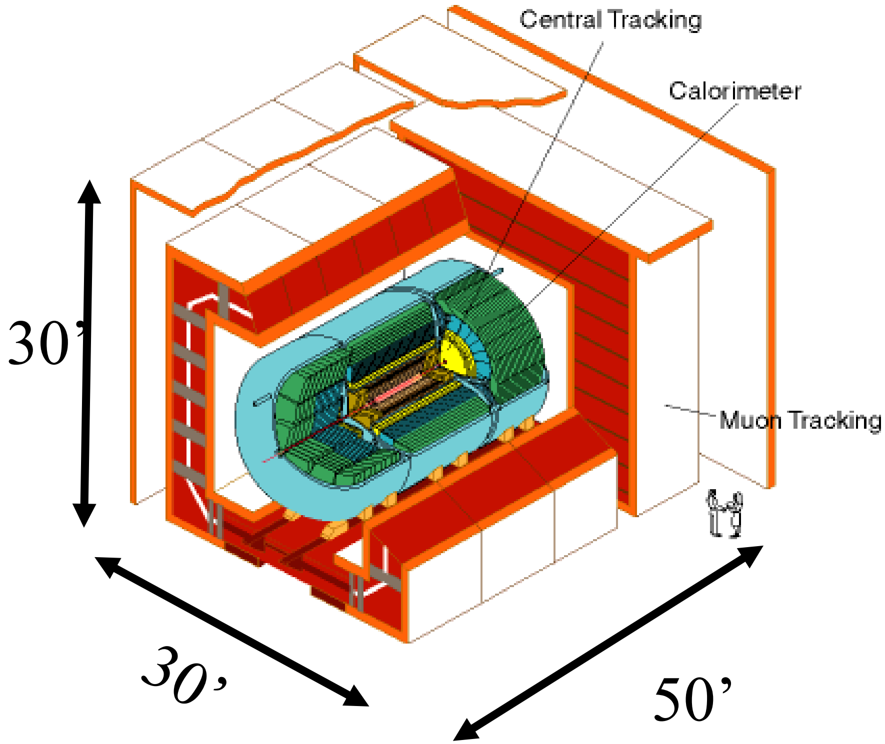




Fermilab: http://www.fnal.gov/ ; DØ: http://www-d0.fnal.gov/

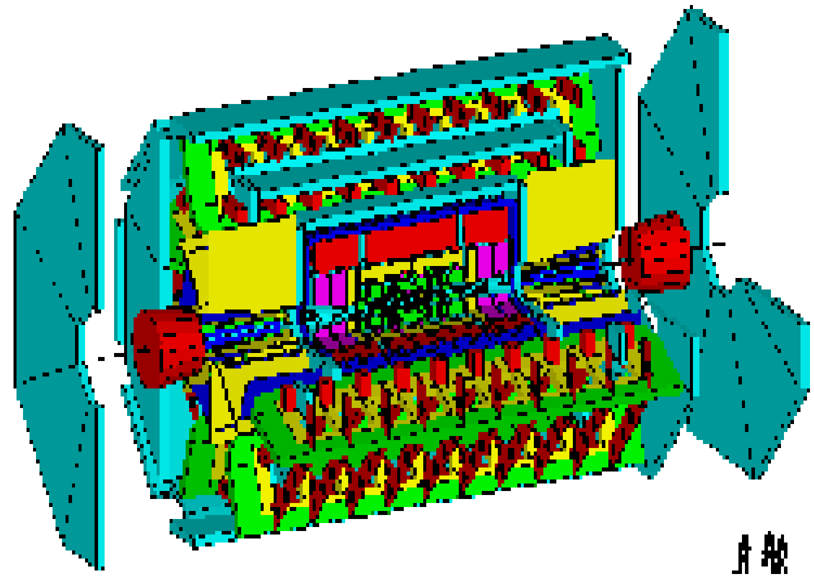
CERN: http://www.cern.ch/ ; ATLAS: http://atlas.web.cern.ch/

DØ Detector



- Weighs 5000 tons
- As tall as a 5 story building
- Can inspect 3,000,000 collisions/second
- Record 100 collisions/second
- Records 10 Mega-bytes/second
- Recording 0.5×10^{15} (500,000,000,000,000) bytes per year (0.5 PetaBytes).

ATLAS Detector



- Weighs 10,000 tons
- As tall as a 10 story building
- Can inspect 1,000,000,000 collisions/second
- Recors 200 -300 collisions/second
- Records 300 Mega-bytes/second
- Will record 2.0×10^{15} (2,000,000,000,000,000) bytes each year (2 PetaByte).

Need for Standards and Units

- Three basic quantities for physical measurements
  - Length, Mass, and Time
- Need a language so that people can understand each other (How far is it to Chicago? 1000)
- Consistency is crucial for physical measurements
  - The same quantity measured by one person must be comprehensible and reproducible by others
- A system of unit called **SI** (*System International*) established in 1960
  - Length in meters (m)
  - Mass in kilo-grams (kg)
  - Time in seconds (s)

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

Prefixes and their meanings

- 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}

- 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}

Impress your friends!

Examples 1.3 and 1.4 for Unit Conversions

- Ex 1.3: A silicon chip has an area of 1.25in^2. Express this in cm^2.

$$1.25\ \text{in}^2 = 1.25\ \text{in}^2 \times \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^2$$

$$= 1.25\ \text{in}^2 \times \left(\frac{6.45\ \text{cm}^2}{1\ \text{in}^2}\right)$$

$$= 1.25 \times 6.45\ \text{cm}^2 = 8.06\ \text{cm}^2$$

- Ex 1.4: Where the posted speed limit is 65 miles per hour (mi/h or mph), what is this speed (a) in meters per second (m/s) and (b) kilometers per hour (km/h)?

$$1\ \text{mi} = 5280\ \text{ft}\left(\frac{12\ \text{in}}{1\ \text{ft}}\right)\left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)\left(\frac{1\ \text{m}}{100\text{cm}}\right) = 1609\ \text{m} = 1.609\ \text{km}$$

(a) $$65\ \text{mi/h} = 65\ \text{mi}\left(\frac{1609\ \text{m}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 29.1\ \text{m/s}$$

(b) $$65\ \text{mi/h} = 65\ \text{mi}\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right) = 104\ \text{km/h}$$

Oops, what about sig. figs.?

About how fast did Usain run in MPH?

Uncertainties

- Physical measurements have limited precision, no matter how good they are, due to:

Statistical { Number of measurements

Systematic { Quality of instruments (meter stick vs micrometer)
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

- Significant figures denote the precision of the measured values
  - Significant figures: non-zero numbers or zeros that are not place-holders
    - 34 has two significant digits; 34.2 has 3; 0.001 has one because the 0's before 1 are place holders, 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:
      - $31400000=3.14\times10^{7}$
      - $0.00012=1.2\times10^{-4}$

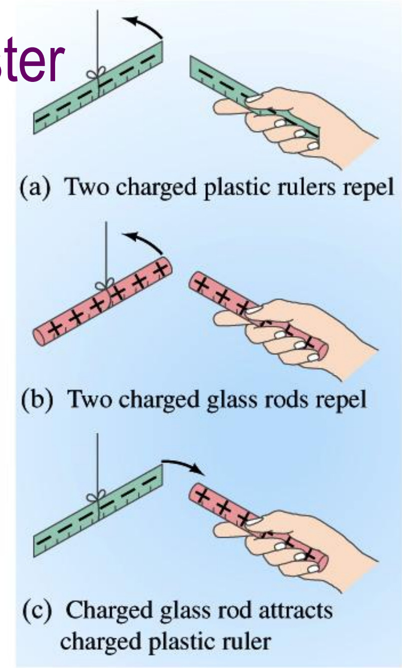
Significant Figures

- Operational rules:
  - Addition or subtraction: Keep the **smallest number of decimal places** in the result, independent of the number of significant digits: 34.001+120.1=154.1
  - Multiplication or Division: Keep the **number of significant figures of the operand with the least S.F.** in the result: 34.001x120.1 = 4083, because the smallest number of significant figures is 4.
  - **For homework may need to get this right!**

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
  - Example: Rub feet on carpet and zap your little sister
- Two types of electric charge
  - Like charges repel while unlike charges attract
  - Benjamin Franklin referred to the charge on a glass rod as the positive, arbitrarily. Thus the charge that attracts a 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 the Atom

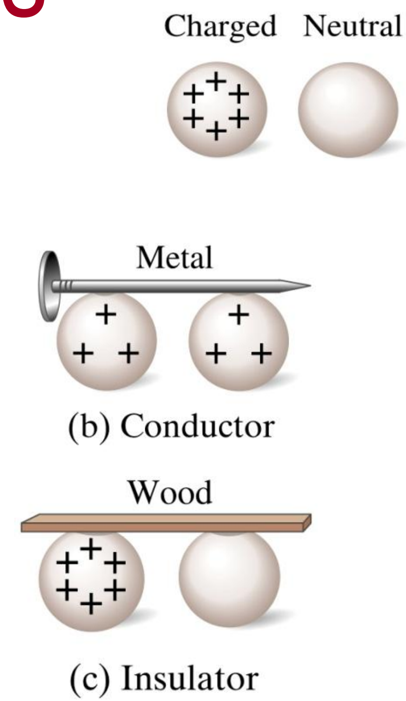
- It has been understood through the past century that an atom consists of
  - A positively charged heavy core ← What is the name?
    - This core is the nucleus and consists of neutrons and protons.
  - Many negatively charged light particles surround the core ← What is the name of these light particles?
    - These are called electrons
    - How many of these?

As many as the number of protons!!

- 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 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

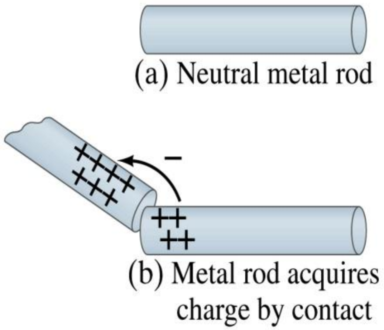
- Picturetwo metal balls, one of which is charged
- What will happen if they are connected by
  - A metallic object?
    - Charge is transferred, until the charge is evenly distributed
    - These objects are called conductors of electricity.
  - A wooden object?
    - No charge is transferred
    - These objects are called insulators.

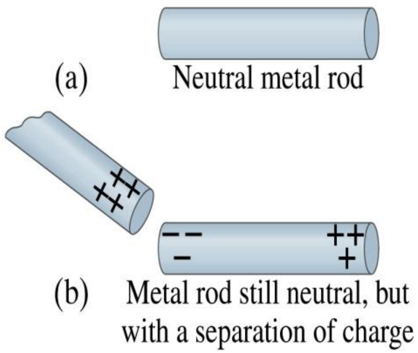


- Metals are generally good conductors whereas most other materials are insulators.
  - A third kind of materials called semi-conductors, like silicon or germanium ➔ conduct only in certain conditions
- Atomically, conductors have loosely bound electrons while insulators have tightly bound electrons!

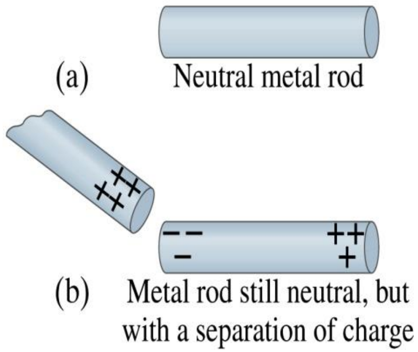
Induced Charge

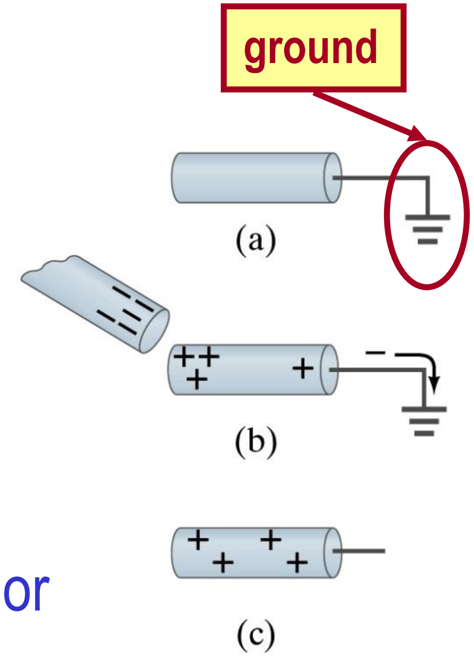
- When a positively charged metal object is brought close to an uncharged metal object
  – If the objects touch each other, the free electrons in the neutral ones are attracted to the positively charged object and some will pass over to it, leaving the neutral object positively charged.
  – If the objects get close, the free electrons in the neutral object still move within the metal toward the charged object leaving the opposite end of the object positively charged.
    - The charges have been "induced" in the opposite ends of the object.





Induced Charge





- We can induce a net charge on a metal object by connecting a wire to ground.
  - The object is "grounded" or "earthed".
- Since it is so large and conducts, the Earth can give or accept charge.
  - The Earth acts as a reservoir for charge.
- If the negative charge is brought close to a neutral metal rod
  - Positive charges in the neutral rod will be attracted by the negatively charged metal.
  - The negative charges in the neutral metal will gather on the opposite side, transferring through the wire to the Earth.
  - If the wire is cut, the metal bar has net positive charge.
- An **electroscope** is a device that can be used for measuring charge – How?