Physics 253
Fundamentals of Physics I: Mechanics

- Dr. or Prof. Blazey
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    - Day: MWF @ NIU/ TTh @ Fermilab
    - Office Hours: MWF 11AM – Noon or call for appointment

Course Overview

- Physics—the science of energy and matter
  - Mechanics—the motion of physical objects
  - Physical quantities describe behavior & are related to each other
  - Theoretical relations predict behavior
- Mathematics
  - Tool for understanding physics
  - Algebra and trigonometry are essential (MATH 155)
  - Calculus will be used sparingly (co-requisite MATH 229)

Units

I. Measurement and motion
II. Motion in two and three dimensions
III. Newton’s laws of force
IV. Circular motion and gravity
V. Conservation of energy
VI. Conservation of momentum
VII. Conservation of angular momentum

Web Pages

- Physics 253 Portal:
  - http://nicadd.niu.edu/people/blazey/Physics_253_2006/Physics_253_2006.htm
    - Introduction
    - Goals
    - Syllabus
    - Assignments
    - Grading
    - Contact
- Text:
  - www.prenhall.com/giancoli

Class Hours

- Presentations
  - Slides that follow text, but are different
  - Student responsible for both
- Examinations
  - Four Quizzes approximately one per month
  - A comprehensive Final
  - Multiple Choice, short answer, & Problems

Problems

- One problem set per unit
- Associated sets due day of quiz
- Solution and assistance in the "Help Room" FR 225
- Use TA and Instructors office hours for help!
- These are easy points!

Labs – Every Thursday

- **Spring 2007 - Dr. Fortner**
- Sections will alternate between the two types of laboratories, and will alternate rooms as well.
- <u>Experimental laboratories</u> meet in room FR 235. This is in Faraday Hall, the building farther from Normal Rd.
- <u>Problem laboratories</u> meet in room FW 233. This is in Faraday West, the building closer to Normal Rd.
- For details see: http://www.physics.niu.edu/~physlabs/PHYS253S.html

Grading

- Components:
  - Four quizzes - 50 points each – 200 points maximum.
  - Final exam - 100 points - 100 points maximum.
  - Unit problem sets - 12 points each, due before quiz – 84 points maximum.
  - Fourteen laboratories - 15 points each; reports typed, due at the next lab - 210 points maximum. (Note: Each student must get 120 points or more in the laboratory to pass the course, regardless of other scores.)
  - Extra credit – Web exercises from the text companion website - 10 points each, due the day of the quiz - 70 points maximum.

- Grading scale:
  - A : 536 or more points
  - B : 475 to 535 points
  - C : 416 to 474 points
  - D : 356 to 415 points
  - F : less than 355 points
  - (extra credit can move you up a full grade)

Tips on how to do well!

I. Read the material before lectures
II. Listen in class, take notes sparingly
III. Do the problems, these are key to understanding
IV. Read the material again after doing problems, this locks down the concepts
V. Take advantage of the extra credit
VI. If you don't understand, ask!

Laboratories

- Experimental Labs (FR 235)
  - Measurement
  - Data Analysis
  - Presentation
- Problem Labs (FW233)
  - Story Problems
  - Equation Handling
  - Solution Strategy

One pair for each unit

Who are your classmates?

- There are 119 of you (to date)
- By Class
  - Frosh: 66
  - Soph: 31
  - Junior: 13
  - Senior: 9

- By Major (more than five)
  - Mech. Eng.: 32
  - Elec. Eng: 21
  - Meteorology: 11
  - Industrial-Systems Eng: 11
  - Chem.: 7
  - Undecided: 7
  - Education (Math, Phys, Chem, Pre-Elem): 7
  - Bio.: 6
  - Others: 17

- Let's get to it…starting with some fundamentals…
  - Measurement & Uncertainty
  - Significant Figures
  - Units

The Nature of Science, Models & Theories

- A creative interplay between:
  - Observations which are explained or interpreted by
  - Models & Theories which are, in turn, tested by new and refined observation.
- A successful model which explains a broad set of phenomena with precision and predictive power becomes a theory.
- But even the most successful theory will eventually be superseded by new circumstances and measurements.
  - The extension of classical mechanics by relativity and quantum mechanics occurred because measurements reached the very small and very fast.

Measurement & Uncertainty

- A foundation of physics and so a good place to start
- We are surrounded by measuring devices (both analog and increasingly digital)
  - A ruler (analog)
  - Clocks (digital, with hands analog)
  - Bathroom scale (digital, with hands analog)
  - Thermometer (digital, with fluid analog)

- Uncertainty associated with every measurement
  - Flat-out mistakes
    - Miscounting groups during a census
    - Reading the speedometer from an angle
  - Generally limited by the smallest measurement division available and you must round or interpolate
    - One pound of pressure on your air gauge
    - One degree on your thermostat

Uncertainty

- Consequently it's necessary to report the estimated uncertainty of any measurement.
- This can be given in absolute or relative (percentage) terms.
- Consider using a meter stick to measure the height of your baby sibling at 91 +/- 1 centimeters.
  - The absolute estimated uncertainty would be 1 cm. That is, her height could be anywhere between 90 and 92 cm.
  - The relative or percent estimated uncertainty would be: (1 cm/91 cm) x 100% or ~1%.
- Occasionally you'll need to estimate the estimated uncertainty, as the last digit given. You have to assume this for a digital device.

Significant Figures

- The number of reliably known digits for a measurement.
- Any value is expressed by some number of digits.
- The number of digits (without left side zeroes) is the number of *significant figures*.
- With no decimal point, skip right side zeroes.
- Examples:
  - 38 2 digits, 2 significant figures
  - 5.06 3 digits, 3 significant figures
  - 0.0041 5 digits, 2 significant figures
  - 7,000. 4 digits, 4 significant figures (note the decimal point!)
  - 2,000 4 digits, 1 significant figure

Rules for Using Significant Figures

- Addition or subtraction:
  - Keep the significant figures to the decimal place of the *least* accurate value, rounding as needed.
  - Examples:
    - 4.361 + 14.2 = 18.6
    - 12000 + 364 = 12000
- Multiplication or Division
  - Generally keep the same number of significant figures as the value with the fewest, rounding as needed.
    - $4.361 \times 14.2 = 61.9$
    - $12000 \times 364 = 4.4 \times 10^6$

Keeping excess significant figures
Is a scientific faux pas!

Significant Figure Pitfalls

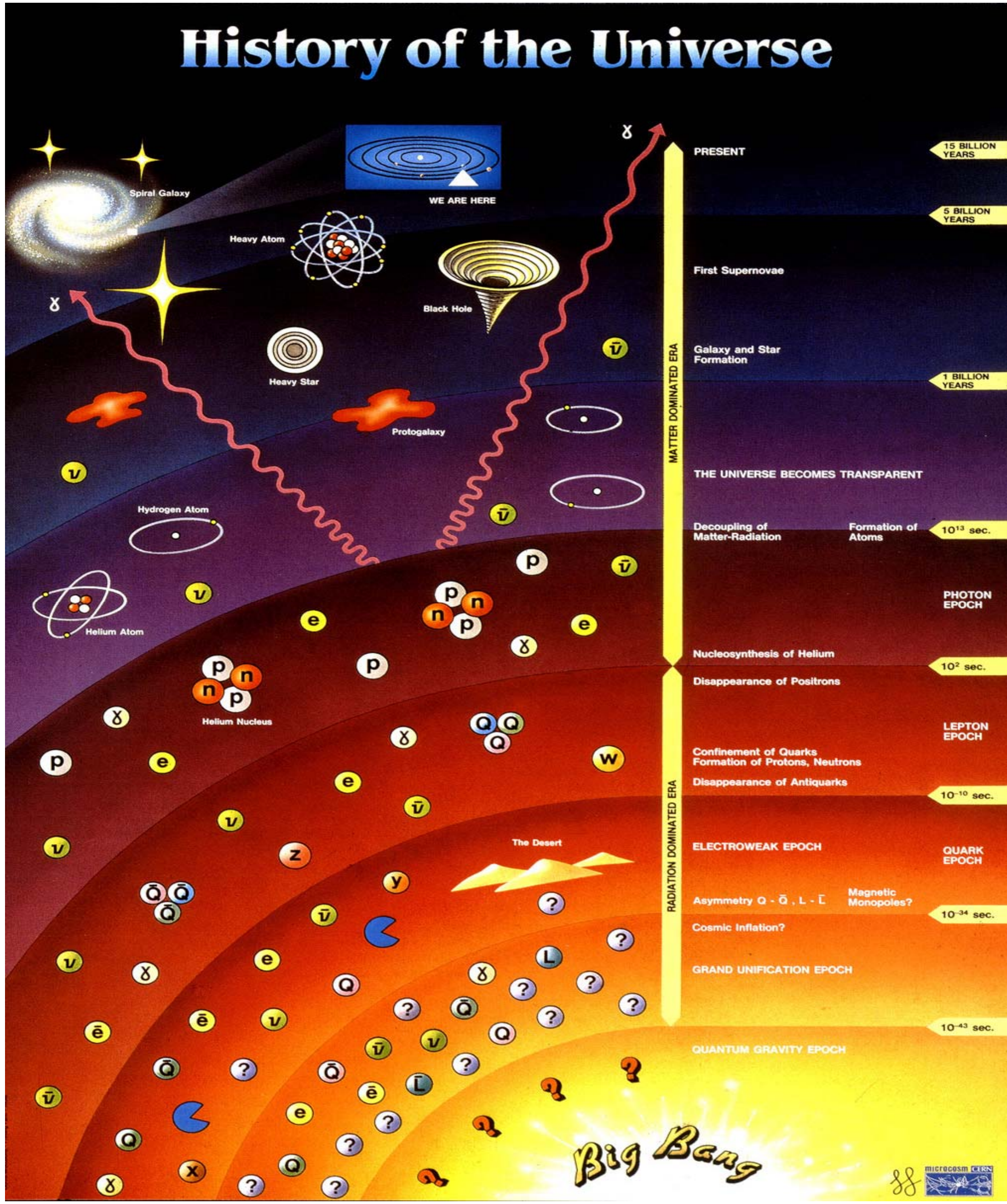
- Watch out for calculators - they don't think for you and can't evaluate significant figures
- The rule isn't infallible
  - Consider 97/92 = 1.05 → 1.1
  - Note both numbers were known to about 1% but the rounded number is only good to 10%.
  - 1.05 makes better sense since it's good to ~1%.
  - Use the rule, but check % uncertainties for realism.

Units

- All measurements must have units to be meaningful!
- Endlessly interesting history of units!
- Measurements given relative to standard units
  - For instance, the "foot" is sometimes associated with the royal extremity of King Henry I. (It can actually can be traced to the Sumerians.)
  - Now-a-days the unit standards are given very precise definitions.
- In fact, systems are set up for fundamental units
  - British: foot, pound, second
  - Metric System: meter, kilogram, second

Time

- The unit of time originally was based on the day and the year, again thanks to the Sumerians.
- The second was 1/60 * 1/60 *1/24 of a day.
- We now know that the day is getting longer and "leap seconds" are added every few years.
- In the 20th century the second was measured based on the timing of atoms.
- The SI unit of time is the *second* (s)
- Range: lifetime of fundamental particles (10^{-23} s) to the age of the universe (10^{18} s)



15Billion yrs

10^{-43} s

Length

- The oldest standards of length were based on the human body.
- The metric system defined the meter in terms of the Earth: 1/10,000,000 from the pole to the equator.
- The meter is now defined in terms of the second and speed of light.
- The SI unit of length is the *meter* (m)
- Range: size of a proton (10^{-15} m) to farthest galaxy (10^{26} m)

Mass

- Standard weights have been maintained for centuries.
- Weight and mass were thought to be the same.
- Now a standard 1 kilogram mass of platinum-iridium is kept in Paris.
- The SI unit of mass is the *kilogram* (kg)
- Range: electron (10^{-30} kg) to Galaxy (10^{41} kg)

Systems of Units

- We will use the "Systeme International" or SI units exclusively in this course.
- SI standards are the meter, second, and kilogram.
- Other systems exist, most notably
  - cgs system: centimeter, gram, second
  - British Engineering: foot, pound (for force), second.

Unit Prefixes

- Prefixes on units are used to represent powers of ten.
- Prefixes denote powers of ten from –18 to +18 in steps of three.
- Example: a kilometer is 10^3 meters or 1000 meters.

Most Common

- micro (μ) 10^{-6}
- milli (m) 10^{-3}
- kilo (k) 10^3
- mega (M) 10^6

Extreme units

- yocto (c) 10^{-24}
- yotta (d) 10^{24}

Base and Derived Units

- The physical units can be base units or derived.
- Base units are given by a standard, in SI
  - The familiar: length, time, mass
  - The not so familiar:
    - current (Ampere or A)
    - temperature (Kelvin or K)
    - amount of substance (mole or mol)
    - luminous intensity (candela or cd)
- All other units are derived from the base units
  - Speed m/s
  - Force (kg-m/sec^2)
  - Area (m^2)