PHYS 1441 – Section 002
Lecture #2

Wednesday, Sept. 1, 2010
Dr. Jaehoon Yu

- Brief history of physics
- Uncertainties
- Significant Figures
- Standards and units
- Dimensional Analysis

Announcements

- Homework registration
  - 62/77 registered as of noon today
    - 24/62 submitted the homework
  - You MUST register AND submit the answer for 100% credit
  - Homework registration closes tomorrow, Thursday, at midnight ➔ Please do this ASAP!!
- E-mail subscription
  - 42/77 subscribed!
    - 5 point extra credit if done by midnight tonight
    - 3 point extra credit if done by midnight Friday
  - Many of you CCed me. This confuses the system. So please do not do this but follow the instruction on the class web page.
- No class coming Monday, Sept. 6
- Reading assignment Appendices A.1 – A.8
  - Remember the quiz at the beginning of the class next Wednesday, Sept. 8

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
  - 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, no matter how 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

- Significant figures denote the precision of the measured values
  - 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
      - 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 notations for simplicity:
      - $31400000=3.14\times10^{7}$
      - $0.00012=1.2\times10^{-4}$

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+ 3.1= $\boxed{15.1}$
  - Multiplication or Division: Keep the **smallest significant figures** in the result: 12.001 x 3.1 = $\boxed{37}$, because the smallest significant figures is ?.

What does this mean? **The worst precision determines the precision the overall operation!!**

Needs for Standards and Units

- Seven basic quantities for physical measurements
  - Length, Mass, Time, Electric Current, Temperature, Amount of substance and Luminous intensity
- Need a language that everyone can understand each other
  - Consistency is crucial for physical measurements
  - The same quantity measured by one must be comprehendible and reproducible by others
  - Practical matters contribute
- A system of unit called **SI** (*System Internationale*) was established in 1960
  - **Length** in meters (m)
  - **Mass** in kilo-grams (kg)
  - **Time** in seconds (s)

Definition of Three Relevant Base Units

SI Units	Definitions
1 *m (Length)* = *100 cm*	One meter is the length of the path traveled by light in vacuum during the time interval of 1/299,792,458 of a second.
1 *kg (Mass)* = *1000 g*	It is equal to the mass of the international prototype of the kilogram, made of platinum-iridium in International Bureau of Weights and Measure in France.
1 *s (Time)*	One second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Cesium 133 (C^{133}) atom.

- *There are total of seven base quantities (see table 1-5 in page 10)*
- *There are prefixes that scales the units larger or smaller for convenience (see pg. 9)*
- *Units for other quantities, such as Newtons for force and Joule for energy, for ease of use*

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}

International Standard Institutes

- International Bureau of Weights and Measure http://www.bipm.fr/
  - Base unit definitions: http://www.bipm.fr/enus/3_SI/base_units.html
  - Unit Conversions: http://www.bipm.fr/enus/3_SI/
- US National Institute of Standards and Technology (NIST) http://www.nist.gov/

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….

Examples for Unit Conversions

- Ex: An apartment has a floor area of 880 square feet (ft^2). Express this in square meters (m^2).

What do we need to know?

$$880\ \mathrm{ft}^2 = 880\ \mathrm{ft}^2 \times \left(\frac{12\mathrm{in}}{1\mathrm{ft}}\right)^2 \left(\frac{0.0254\ \mathrm{m}}{1\ \mathrm{in}}\right)^2$$

$$= 880\ \cancel{\mathrm{ft}^2} \times \left(\frac{0.0929\ \mathrm{m}^2}{1\ \cancel{\mathrm{ft}^2}}\right)$$

$$= 880 \times 0.0929\ \mathrm{m}^2 \approx 82\mathrm{m}^2$$

Ex 1.5: Where the posted speed limit is 55 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)?

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

(a) $$55\ \mathrm{mi/h} = (55\ \mathrm{mi})\left(\frac{1609\ \mathrm{m}}{1\ \mathrm{mi}}\right)\left(\frac{1}{1\ \mathrm{h}}\right)\left(\frac{1\ \mathrm{h}}{3600\ \mathrm{s}}\right) = 25\ \mathrm{m/s}$$

(b) $$55\ \mathrm{mi/h} = (55\ \mathrm{mi})\left(\frac{1.609\mathrm{km}}{1\ \mathrm{mi}}\right)\left(\frac{1}{1\ \mathrm{h}}\right) = 88\ \mathrm{km/hr}$$