PHYS 1441 – Section 002
Lecture #2

Wednesday, Jan. 16, 2008

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

Announcements

- Reading assignment #1: Read and follow through all sections in appendices C, D and E by Tuesday, Jan. 22
  - There will be a quiz on Wednesday, Jan. 23, on this reading assignment
- E-mail list: 16 of you subscribed to the list so far
  - 5 point extra credit if done by this Friday, Jan. 18
  - 3 point extra credit if done by Wednesday, Jan. 23
- 19 of you have registered for homework roster, of whom 8 submitted homework #1
  - Remember that you need to download and submit homework #1 for full credit!!
  - You need a UT e-ID and password to log-in and download homework
  - If you don't have them request e-id on the web http://www.utexas.edu/eid
- No class next Monday, Jan. 21, Martin Luther King day
  - But homework#1 is still due 9pm that day

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

⇒Theory works generally under restricted conditions

⇒Discrepancies between experimental measurements and theory are good for improvements

⇒Improves our everyday lives, though some laws can take a while till we see them amongst us

Models, Theories and Laws

- Models: An analogy or a mental image of a phenomena in terms of something we are familiar with
  - 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 → The statement must be found experimentally valid
- Principles: Less general statements of how nature behaves
  - Has some level of arbitrariness

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)
  - Discovery of radioactivity
  - 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?

Needs for Standards and Units

- Three basic quantities for physical measurements
  - Length, Mass and Time
- 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 Base Units

SI Units	Definitions
1 *m (Length)* = *100 cm*	One meter is the length of the path traveled by light in vacuum during a 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 alloy kept 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 prefixes that scales the units larger or smaller for convenience (see pg. 7)*
- *Units for other quantities, such as Kelvins for temperature, for easiness of use*

Prefixes, expressions 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}
- zetta (Z): 10^{21}
- yotta (Y): 10^{24}
- 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}

Table 1.2

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 m	3.281	ft
1 hr	60	minutes
1 hr	3600	seconds
And many	More	Here….

Examples for Unit Conversions

- Ex 1: The highest waterfall in the world is Angel Falls in Venezuela, with a total drop of 979.0m. Express this drop in feet.

$$979.0m = 979.0m \times \left(\frac{3.281\,feet}{1\text{ m}}\right)$$

$$= 979.0m \times \left(\frac{3.281\text{ feet}}{1\text{ m}}\right)$$

$$= 979.0 \times 3.281\text{ feet} = 3212\text{ feet}$$

What do we need to know?

- Ex 2 : Express the speed limit 65 miles per hour (mi/h or mph) in terms of meters per second (m/s).

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

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

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

Estimates & Order-of-Magnitude Calculations

- Estimate = Approximation
  - Useful for rough calculations to determine the necessity of higher precision
  - Usually done under certain assumptions
  - Might require modification of assumptions, if higher precision is necessary
- Order of magnitude estimate: Estimates done to the precision of 10s or exponents of 10s;
  - Three orders of magnitude: 10^3=1,000
  - Round up for Order of magnitude estimate; $8\times10^7 \sim 10^8$
  - Similar terms: "Ball-park-figures", "guesstimates", etc

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

- Significant figures denote the precision of the measured value
  - Significant figures: non-zero numbers or zeros that are not place-holders
    - How many significant figures? 34, 34.2, 0.001, 34.001
      - 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 <u>smallest number of decimal place</u> in the result, independent of the number of significant digits: 12.001+ 3.1= 15.1
  - Multiplication or Division: Keep the <u>smallest significant figures</u> in the result: 12.001 x 3.1 = 37 , because the smallest significant figures is ?.