PHYS 1441 – Section 002
Lecture #2

Monday, Feb. 2, 2009

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- What is Physics?
- Brief history of physics
- Standards and units
- Dimensional Analysis
- Coordinate Systems

Today's homework is homework #2, due 9pm, Monday, Feb. 9!!

Announcements

- Reading assignment #1: Read and follow through all sections in appendices A1 – A8 by Tuesday, Feb. 3
  - There will be a quiz on Wednesday, Feb. 4, on this reading assignment
- E-mail list: 39 of you subscribed to the list so far
  - 3 point extra credit if done by Wednesday, Feb. 4
- 76 of you have registered for homework roster, of whom 61 submitted homework #1
  - Wow! Impressive!!
  - 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
  - Will extend the due for homework #1 to 9pm today, Monday, Feb. 2

Why do Physics?

Exp. { • To understand nature through experimental observations and measurements

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

Brief History of Physics

- AD 18^{th} century:
  - Newton's Classical Mechanics: A theory of mechanics based on observations and measurements
- AD 19^{th} Century:
  - Electricity, Magnetism, and Thermodynamics
- Late AD 19^{th} and early 20^{th} 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, 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 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 notation for simplicity:
      - $31400000=3.14\times10^{7}$
      - $0.00012=1.2\times10^{-4}$

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 ?.

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

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 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. 9)*
- *Units for other quantities, such as Kelvins for temperature, 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?

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

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

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

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)?

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

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

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

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