PHYS 1443 – Section 004
Lecture #2

Thursday, Aug. 28, 2014

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- How to study for this course?
- Brief history of physics
- Standards and units
- Dimensional Analysis

Today's homework is homework #2, due 11pm, Thursday, Sept. 4 !!

Announcements

- Homework registration: 14/20 have registered!
  - The roster closes at 11pm tonight!
  - The deadline for the homework #1 with only 4 problems is also at 11pm tonight!
    - Remember, all homeworks have the same weights!
  - I need to approve your enrollment requests so please take an action ASAP!

Special Project #1 for Extra Credit

- Find the solutions for $yx^2-zx+v=0$ ➔ 5 points
  - X is the unknown variable, and y, z and v are constant coefficients!
  - You cannot just plug into the quadratic equations!
  - You must show a complete algebraic process of obtaining the solutions!
- Derive the kinematic equation $v^2 = v_0^2 + 2a(x - x_0)$ from first principles and the known kinematic equations ➔ 10 points
- You must **show your OWN work in detail** to obtain the full credit
  - Must be in much more detail than in this lecture note!!!
  - Please do not copy from the lecture note or from your friends. You will all get 0!
- Due Thursday, Sept. 4

How to study for this course?

- Keep up with the class for comprehensive understanding of materials
  - Come to the class and participate in the discussions and actively participate in problem solving sessions
  - Follow through the lecture notes
  - Work out example problems in the book yourself without looking at the solution
  - Have many tons of fun in the class!!!!!
- Keep up with the homework to put the last nail on the coffin
  - Do not wait till you are done with all the problems. One can always input the answers as you solve problems.
  - Form a study group and discuss how to solve problems with your friends, then work the problems out yourselves!
- Prepare for upcoming classes
  - Read the textbook for the material to be covered in the next class
- The extra mile
  - Work out additional problems in the back of the chapter starting the easiest problems to harder ones

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

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

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

Needs for Standards and Units

- Physics is based on precise measurements and comparisons
- A rule for how things are measured and compared is essential
- Need experiments to establish the units of such measurements
- Precise measurement is necessary for practical uses and for fully understanding the rules of nature
- Units define a unique name assigned to the measure of the given quantity
  - Consistency is crucial for physical measurements and comparisons
  - The same quantity measured by one must be comprehendible and reproducible by others
  - Practical matters contribute

Needs for Standards and Units

- Seven fundamental quantities for physical measurements
  - Length, Mass, Time, Electric Current, Temperature, the Amount of substance and the Luminous intensity
  - All other physical quantities can be derived from these
- A system of unit called **SI** (*System Internationale*) was established in 1971
- The three base quantities relevant for this course are
  - **Length** in meters (m)
  - **Mass** in kilo-grams (kg)
  - **Time** in seconds (s)
- These scales are called the human scales

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 Appendix A)*
- *There are prefixes that scales the units larger or smaller for convenience (see T.1-2 pg. 2)*
- *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?

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

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

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

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

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

- Denote the precision of the measured values
  - The number 80 implies precision of +/- 1, between 79 and 81
    - If you are sure to +/-0.1, the number should be written 80.0
  - 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 to position "."
      - 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:
      - $31400000=3.14\text{x}10^{7}$
      - $0.00012=1.2\text{x}10^{-4}$
    - How about 3000?
      - This book assumes all 0's are significant but it could be different in other cases!

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= 15.1
  - Multiplication or Division: Keep the **smallest number of significant digits** 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!!**

In English? **Can't get any better than the worst measurement!**