College Physics

Chapter 1
Introduction

Theories and Experiments

- The goal of physics is to develop theories based on experiments
- A theory is a mathematical expression, about how a system works
- The theory makes predictions about how a system should work
- Experiments check the theories' predictions
- Every theory is a work in progress

From Astronomical scales..

~ 10^{21} m

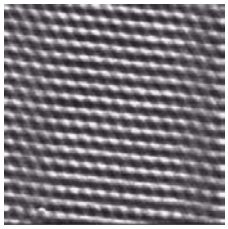
http://antwrp.gsfc.nasa.gov/apod/archivepix.html

..to planetary scales..

~ 10^{6} m

Why do we always see only one half of the moon?

..to the microscopic and smaller



~ 10^{-10} m

Atomic scale image of graphite taken in the Biswas lab.

Fundamental Quantities and Their Dimension

- Length [L]
- Mass [M]
- Time [T]
  - other physical quantities can be constructed from these three

You will need a few more in PHY 2054

Units

- To communicate the result of a measurement for a quantity, a *unit* must be defined
- Defining units allows everyone to relate to the same fundamental amount

Systems of Measurement

- Standardized systems
  - agreed upon by some authority, usually a governmental body
- SI -- Systéme International
  - agreed to in 1960 by an international committee
  - main system used in this text
  - also called mks for the first letters in the units of the fundamental quantities

Systems of Measurements, cont

- cgs – Gaussian system
  - named for the first letters of the units it uses for fundamental quantities
- US Customary
  - everyday units
  - often uses weight, in pounds, instead of mass as a fundamental quantity

Length

- Units
  - SI – meter, m
  - cgs – centimeter, cm
  - US Customary – foot, ft
- Defined in terms of a meter – the distance traveled by light in a vacuum during a given time

Mass

- Units
  - SI – kilogram, kg
  - cgs – gram, g
  - USC – slug, slug
- Defined in terms of kilogram, based on a specific cylinder kept at the International Bureau of Weights and Measures

Time

- Units
  - seconds, s in all three systems
- Defined in terms of the oscillation of radiation from a cesium atom

Dimensional Analysis

- Technique to check the correctness of an equation. Both sides of equation must have the same dimensions
- Dimensions (length, mass, time, combinations) can be treated (kind of) as algebraic quantities

Uncertainty in Measurements

- There is uncertainty in every measurement, this uncertainty carries over through the calculations
  - need a technique to account for this uncertainty
- We will use rules for significant figures to approximate the uncertainty in results of calculations

Significant Figures

- A significant figure is one that is reliably known
- All non-zero digits are significant
- Zeros are significant when
  - between other non-zero digits
  - after the decimal point and another significant figure
  - can be clarified by using scientific notation

Operations with Significant Figures

- Accuracy – number of significant figures
- When multiplying or dividing two or more quantities, the number of significant figures in the final result is the same as the number of significant figures in the least accurate of the factors being combined

Operations with Significant Figures, cont.

- When adding or subtracting, round the result to the smallest number of decimal places of any term in the sum
- If the last digit to be dropped is less than 5, drop the digit
- If the last digit dropped is greater than or equal to 5, raise the last retained digit by 1

Conversions

- When units are not consistent, you may need to convert to appropriate ones
- Units can be treated like algebraic quantities that can "cancel" each other
- See the inside of the front cover for an extensive list of conversion factors
- Example:

$$15.0\ in \times \frac{2.54\ cm}{1\ in} = 38.1\ cm$$

Order of Magnitude

- Approximation based on a number of assumptions
  - may need to modify assumptions if more precise results are needed
- Order of magnitude is the power of 10 that applies

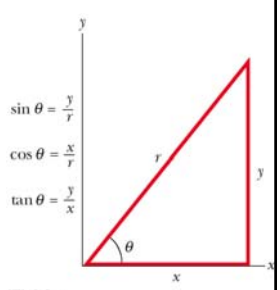
$1{,}000{,}000 = 10^6$

Trigonometry Review

$$\sin\theta = \frac{opposite\ side}{hypotenuse}$$

$$\cos\theta = \frac{adjacent\ side}{hypotenuse}$$

$$\tan\theta = \frac{opposite\ side}{adjacent\ side}$$



More Trigonometry

- Pythagorean Theorem

  $r^2 = x^2 + y^2$
- To find an angle, you need the inverse trig function
  - for example, $\theta = \sin^{-1} 0.707 = 45°$
- Be sure your calculator is set appropriately for degrees or radians