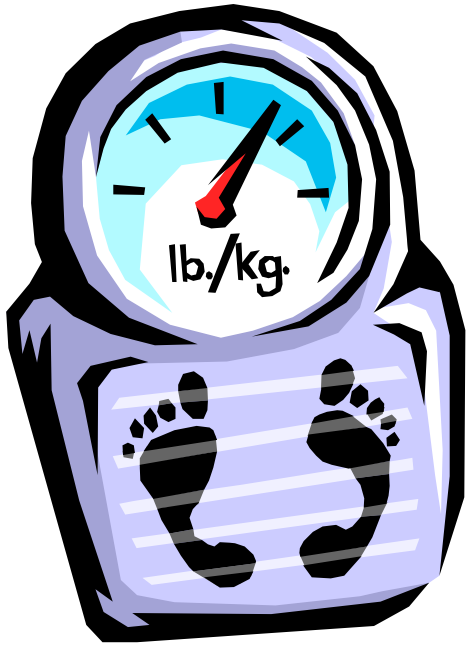
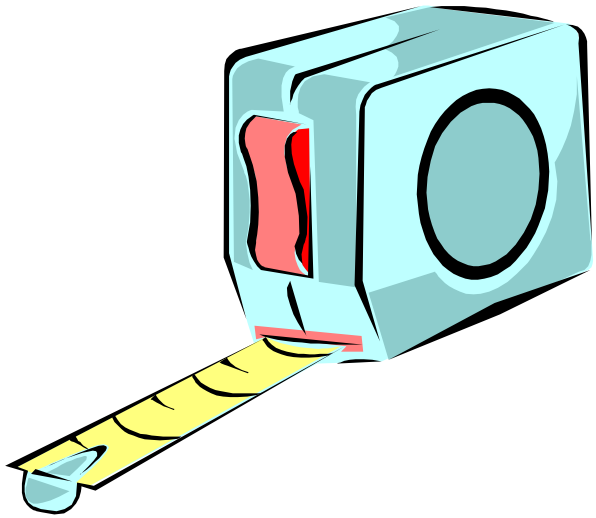
Chapter 1

Preludes





What is Physics?

An *experimentally* based science with a goal of understanding and explaining the *fundamental* principles that govern the physical universe.

"The goal of physics is to predict the future."

–Dr. C. Fronsdal

Studying Physics

1. Four Major Subjects
   a. Classical Mechanics
   b. Thermodynamics and Statistical Mechanics
   c. Electricity and Magnetism
   d. Quantum Mechanics
2. Studied at four different levels
   a. Using Algebra (High School or College)
   b. Using Calculus (Lower division college)
   c. Using Differential Equations (Upper division)
   d. Using graduate mathematics (Graduate School)

Physics Has a Few Major Themes:

This semester:

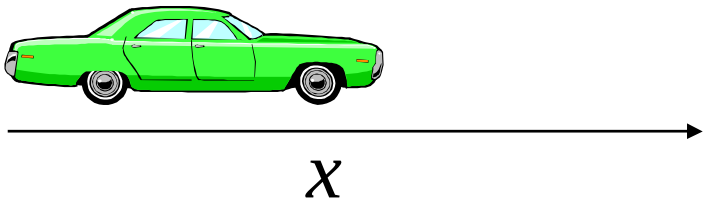
1. Kinematics (how objects move)
2. Dynamics (why objects move)
3. Conservation of Energy
4. Conservation of Momentum

and other ideas usually developed from the major themes.

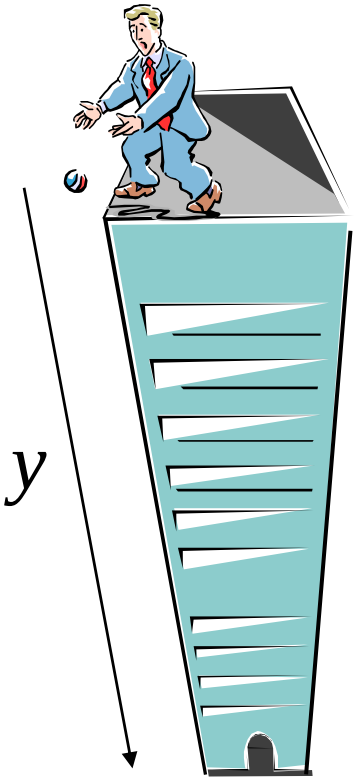
When solving problems, look for the big idea first.

Physics and Mathematics

Equations have meaning:



$x = vt$



Equations allow quantitative reasoning:

$$y = \frac{1}{2} g t^2$$

Units

A number without units is meaningless:

"I'm driving with a speed of 30."

We usually use the International System of Units (Système International (SI)) units.

Length: meter (m)
Time: second (s)
Mass: kilogram (kg)

Problem: A swimming pool is filled with 16,000 cubic feet of water.

a) How many cubic meters is this?

b) If you drain the pool at a rate of 0.5 m^3/s how long (in minutes) will it take to drain the pool?

The answer in the above problem is 450 m^3 even though a calculator would have given 453.0695 m^3. We only use the correct number of significant figures.

Number	Number of Sig. Fig.
25	2
25.0	3
310	2 or 3?
3.10×10^2	3

The rules for using the correct number of significant figures are as follows:

1. When multiplying or dividing numbers, the answer has only as many digits as the number with the least number of significant digits.
   Example: $3.2 \times 5.63 = 18.016 = 18$
2. When adding or subtracting, the number of decimal places in the answer should match the number with the smallest number of decimal places.
   Example: $3.26 + 4.3 = 7.56 = 7.6$

It is a good idea to keep at least one extra significant figure for all intermediate calculations, but to quote your final answer with the correct number of significant figures.

Dimensional Analysis

Dimensional Analysis is the process of using the dimensions of a quantity to

1) Check your answer

or

2) Determine an equation

1) Suppose you were solving for speed, and you got an answer of something like 4.0 m^2/s. You would know, just by looking at the units, that your calculation was wrong since speed must have units of m/s.

Interactive Question

If x is a distance, v is a velocity, and t is a time, which of the following could possibly be a correct equation according to dimensional analysis?

A) $x = vt^2$
B) $x = v^2t$
C) $x = vt$
D) $x = vt/2$
E) either C or D

Rapid Estimating (Order of Magnitude)

Often it is important to get an idea of what an answer should be without actually working out the exact number. The answer you get this way may be perfectly adequate for the question being asked. Even if it is not, a rapid estimate will help you know if the exact answer you calculate is reasonable. When you keep only one significant figure and powers of 10 in this estimate it is called an “order of magnitude” estimate.

Problem: How long would it take to drive a car around the world?

Some reasonable assumptions: The earth has a radius of 6.38×10^3 km around. You can drive maybe 50 miles/hour. You can drive about 10 hours/day.

Problem: How many quarters would it take to fill up Owen field?