1: Introduction

Physics: What is it?

The study of fundamental laws of nature
The study of matter and energy

*a confusing mass of formulas*?

A quantitative study of nature!

Things are measured, so measurements must be described

Units: how measurements are specified

length, mass, time etc.

standardize on METRIC SYSTEM (aka SI units aka mks system)

length: meters

the distance light travels in 1/299,792,458 seconds

about 3.28 feet

a little bit longer than a yard
More on units:

Mass: kilograms

The mass of a particular platinum-iridium alloy cylinder at the International Bureau of Weights and Standards

*Corresponds* to about 2.2 pounds

about the mass of a 1 liter bottle of water/soda

Time: seconds

The amount of time it takes of a cesium-133 atom to complete 9,192,631,770 oscillations (for a particular transition)

At last, a familiar unit!

“one one thousand, two one thousand, three one thousand ...”

Other systems of units:

CGS: centimeter, gram, seconds

English Units: *bleh*!
Powers of 10

- Also called scientific notation.
- This is a way to write a wide range of numbers without taking up too much space.

Examples:
- \(10^2 = 10E2 = 10 \times 10 = 100\)
- \(10^3 = 10E3 = 10 \times 10 \times 10 = 1,000\) (one thousand)
- \(10^6 = 10E6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1,000,000\) (one million)
- \(10^{-1} = 10E-1 = 0.1 = 1/10\) (one tenth)
- \(10^{-2} = 10E-2 = 0.01 = 1/100\)
- \(10^{-3} = 10E-3 = 0.001 = 1/1,000\)
- \(10^{-6} = 10E-6 = 0.000001 = 1/1,000,000\)

1 mile = 5280 ft = 5.280 \times 10^3 ft = 5.28E3 ft

Atoms are about 1 angstrom in diameter = 1E–10 m
Prefixes for units are convenient shorthand for scientific notation

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Abbreviation</th>
<th>Power of Ten</th>
<th>Multiplication Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>femto</td>
<td>f</td>
<td>$10^{-15}$</td>
<td>1/1,000,000,000,000,000,000</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
<td>1/1,000,000,000,000,000</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
<td>1/1,000,000,000</td>
</tr>
<tr>
<td>micro</td>
<td>μ</td>
<td>$10^{-6}$</td>
<td>1/1,000,000</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
<td>1/100</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>$10^{-2}$</td>
<td>1/10</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^{3}$</td>
<td>1,000</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$10^{6}$</td>
<td>1,000,000</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>$10^{9}$</td>
<td>1,000,000,000</td>
</tr>
</tbody>
</table>

check out  http://www.wordwizz.com/pwrsof10.htm  http://microcosm.web.cern.ch/Microcosm/P10/english/P0.html
Dimensional Analysis/Consistency of units

Algebraic equations must always be dimensionally consistent.

You can’t add apples and oranges!

Dimensions of some Common Quantities

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>[L]</td>
</tr>
<tr>
<td>Area</td>
<td>[L^2]</td>
</tr>
<tr>
<td>Volume</td>
<td>[L^3]</td>
</tr>
<tr>
<td>Time</td>
<td>[T]</td>
</tr>
<tr>
<td>Velocity</td>
<td>[L]/[T]</td>
</tr>
<tr>
<td>Acceleration</td>
<td>[L]/[T^2]</td>
</tr>
</tbody>
</table>
Using Dimensional Analysis/Consistency of units
A valid formula must always be dimensionally consistent.

*(You can’t add apples and oranges!)*

\[ x = x_0 + vt \]

\[ [L] = [L] + \left[ \frac{L}{T} \right] [T] \]

\[ [L] = [L] + \left[ \frac{L}{T^2} \right] [T] \]

\[ [L] = [L] + [L] \]

What about \[ x = x_0 + vt + \frac{1}{2} at^2 \]
**Significant Figures:** common way of implicitly indicating uncertainty
number is only expressed using meaningful digits (sig. figs.)
last digit (the *least significant digit* = lsd) is uncertain

<table>
<thead>
<tr>
<th>Number</th>
<th>Digits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>one digit</td>
</tr>
<tr>
<td>3.0</td>
<td>two digits (two significant figures = 2 sig. figs.)</td>
</tr>
<tr>
<td>3.00</td>
<td>three digits, etc.</td>
</tr>
</tbody>
</table>

(300 how many digits?)

**Combining numbers with significant digits**

**Addition and Subtraction:** least significant digit determined by decimal places (result is rounded)

\[
.57 + .3 = .87 = .9 \\
11.2 - 17.63 = -6.43 = -6.4
\]

**Multiplication and Division:** number of significant figures is the number of sig. figs. of the factor with the fewest sig. figs.

\[
1.3 \times 7.24 = 9.412 = 9.4 \\
17.5 / .3794 = 46.12546 = 46.1
\]

**Integer factors and geometric factors** (such as \(\pi\)) have infinite precision

\[
\pi \times 3.76^2 = 44.4145803 = 44.4
\]
converting units

treat units as algebraic quantities

multiplying or dividing a quantity by 1 does not affect its value

\[
1 \text{ m} = 3.281 \text{ ft} \quad \text{so}
\]

\[
\frac{1 \text{ m}}{3.281 \text{ ft}} = 1
\]

\[
316 \text{ ft} = 316 \text{ ft} \times 1
\]

\[
= 316 \text{ ft} \times \frac{1 \text{ m}}{3.281 \text{ ft}}
\]

\[
= 96.3 \text{ m}
\]

Example: What is the volume in SI units of a warehouse that is 20.0 yards long by 10.0 yards wide by 15 feet high?
Estimates and Order of magnitude calculations

an order of magnitude is a (rounded) 1 sig fig calculation, whose answer is expressed as the nearest power of 10.

Estimates should be done “in your head”

check against calculator mistakes!

Example

Estimate the number of raindrops that fall during a thunderstorm which drops a half-inch of rain over an area of 70 square miles.
Succeeding in Physics:

Physics is about applying principles to solve problems!

learn definitions

do problems

Problem solving strategies

Read the entire problem carefully
draw a (simple) diagram
identify what is given

explicit information

implicit information

find mathematical relation(s) between known and unknown quantities
solve the equations (and watch units!)
reality check!