1. UNITS AND PRECISION

1.1 Units
1.2 Unit Conversion
   Ex 1.1: Velocity
   Ex 1.2: Convert Pow
1.3 Units in Problems
1.4 Precision
1.5 Error Analysis
1. Units:
SI: International System of Units

Length: meter [\text{m}]
Time: second [\text{s}]
Mass: kilogram [\text{kg}] = 1000 [\text{g}]

This semester: except for treatment of heat all SI units are combinations of [\text{m, s, kg}]

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1.2. Unit Conversion

Watch Out!!

Everyday use: **often not SI**!
i.e., length = inch, yard, mile
time = minute, hour
mass = ounce (oz), pound (lb)
volume = pint, gallon

Convert all units to SI **before** calculation

Results of a calculation is in SI units if all input quantities are in SI

weight = force
1.2. Unit Conversion: Example 1.1

\[
\frac{60 \text{ miles}}{\text{hour}} \times \frac{1600 \text{ m}}{3600 \text{ s}} = 26.7 \frac{\text{m}}{\text{s}}
\]

\[
1 \text{ mile} = 1600 \text{ m} \rightarrow \frac{1600 \text{ m}}{1 \text{ mile}} = 1 \rightarrow \frac{1 \text{ mile}}{1600 \text{ m}} = 1
\]

\[
1 \text{ hour} = 3600 \text{ s} \rightarrow \frac{3600 \text{ s}}{1 \text{ hour}} = 1 \rightarrow \frac{1 \text{ hour}}{3600 \text{ s}} = 1
\]

multiply with conversion ratio such that unwanted units cancel
1.2. Unit Conversion: Example 1.1

often: \textit{prefix} - powers of 10 \ (table in text)

\text{e.g.,} \quad 1 \ \text{kg} = 1000 \ \text{g} = 10^3 \ \text{g}

1 \ \text{cm} = 0.01 \ \text{m} = 10^{-2} \ \text{m}

\textbf{Remove prefix!} \quad \textbf{Must} \textbf{ be included in}

"converting to SI Units"!
1.2. Unit Conversion: Example 1.2

Conversion of powers:

\[
1 \text{ cm}^2 = 1 \left( \text{cm} \cdot \frac{10^{-2} \text{ m}}{\text{cm}} \right)^2 = 10^{-4} \text{ m}^2
\]

want \( \text{m}^2 \)

convert **inside** the power!

Watch out for powers!

Quiz 1.1: convert power

How many \( \text{m}^3 \) are in a \( \text{cm}^3 \)?
1.2. Unit Conversion: Quiz 1.1

Conversion of powers:

solution: \( 1 \, cm^3 = 1 \left( \frac{cm \cdot 10^{-2} m}{cm} \right)^3 = 10^{-6} m^3 \)
1.3. Units in Problems:

Problem solving:
in text units always carried along - units are a useful aid in problem solving
in the **Text**: insert numerical values **and** their **units**
in **lecture** usually proceed as follows:
- insert numerical values **only**
- convert to **SI**
- results are in **SI**

**Watch Out!** Eliminate **crosscheck** with units
each measured quantity $x$ has a quoted precision $\Delta x$

$x$ can lie anywhere in the "range" $[x - \Delta x, x + \Delta x]

we quote $(x \pm \Delta x)$ as a result
1.4. Precision - in problem solving
work with very accurately measured
quantities, for "CAPA" computer

use a minimum of 3 significant figures !!

e.g. \[ \pi = 3.14 \]
\[ g = 9.81 \text{ (acceleration of gravity)} \]

0.0135759 m = 1.36 \times 10^{-2} m \hspace{1em}, \text{not} \hspace{1em} 0.01 \text{ m} !!
1.5. Error Analysis - in laboratory

We quote \((x \pm \Delta x)\) as a result. 

Lab Manual: Error and Uncertainty (EU)

1. \(\Delta(ax) = a\Delta x; a = \text{const.}\)

2. \(\frac{\Delta x}{x} = \text{"relative error" of} \ x\)

3. \(\frac{\Delta(ax) \mid (ax)}{\Delta x \mid x} = \frac{\Delta x}{x}\)

Often: absolute \(\rightarrow\) relative
1.5. Error Analysis - in laboratory

If one combines measured variables:

**Sums and differences:** add the absolute errors of the variables in quadrature, e.g.

\[(6) \text{ for } S = A \pm B: \Delta S = \sqrt{(\Delta A)^2 + (\Delta B)^2}\]

**Products and Quotients:** add the relative errors of the variables in quadrature, e.g.

\[(7) \text{ for } S = A \times B \text{ or } = A / B: \frac{\Delta S}{S} = \sqrt{(\Delta A / A)^2 + (\Delta B / B)^2}\]
1.5. Error Analysis - in laboratory

Almost every lab: plot a combination of variables such that a straight line graph results, e.g.
for distance \( l \) traveled under constant acceleration

\[
\text{get } l = \frac{1}{2} a t^2 \rightarrow 2l = a t^2 \quad (\text{Ch 2})
\]

if graph the combinations \( y = (2l) \) vs \( x = (t^2) \)

have (recall Algebra) \( y = m x \) with the slope measure the slope and have \( a \)

\[
(10) \quad \text{slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta(2l)}{\Delta(t^2)}
\]