PHYSICS I

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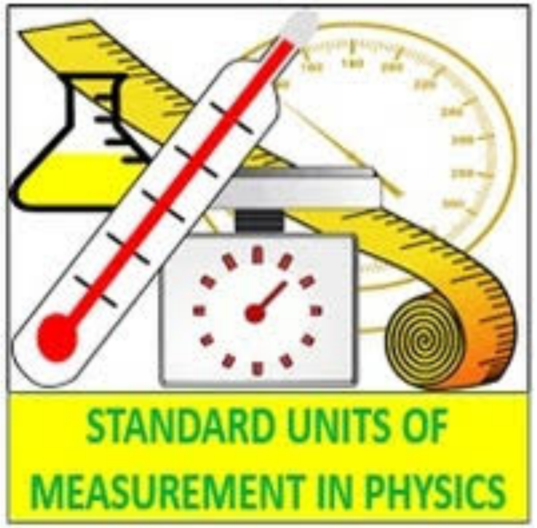
Physics and Measurements



Introduction and Chapter 1

Prefixes

Prefixes correspond to powers of 10.
Each prefix has a specific name.
Each prefix has a specific abbreviation.
The prefixes can be used with any basic units.
They are multipliers of the basic unit.

Examples:

♣ 1 mm = 10^{-3} m

♣ 1 mg = 10^{-3} g

Prefixes, cont.

Prefixes for Powers of 10 in the Metric System

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-18}	atto-	a	10^{-1}	deci-	d
10^{-15}	femto-	f	10^{1}	deka-	da
10^{-12}	pico-	p	10^{3}	kilo-	k
10^{-9}	nano-	n	10^{6}	mega-	M
10^{-6}	micro-	µ	10^{9}	giga-	G
10^{-3}	milli-	m	10^{12}	tera-	T
10^{-2}	centi-	c	10^{15}	peta-	P
			10^{18}	exa-	E

Dimensions and units

Each dimension can have many actual units.
Table 1.5 for the dimensions and units of some derived quantities

TABLE 1.5 *Dimensions and Units of Four Derived Quantities*

Quantity	Area (A)	Volume (V)	Speed (v)	Acceleration (a)
Dimensions	L^2	L^3	L/T	L/T^2
SI units	m^2	m^3	m/s	m/s^2
U.S. customary units	ft^2	ft^3	ft/s	ft/s^2

Dimensional analysis

Technique to check the correctness of an equation or to assist in deriving an equation
Dimensions (length, mass, time, combinations) can be treated as algebraic quantities.

♣ Add, subtract, multiply, divide

Both sides of equation must have the same dimensions.

Any relationship can be correct only if the dimensions on both sides of the equation are the same.

Cannot give numerical factors: this is its limitation !

Dimensional Analysis and example

Given the equation: $x = \frac{1}{2} a t^2$

Check dimensions on each side:

$$L = \frac{L}{\cancel{T^2}} \cdot \cancel{T^2} = L$$

The T^2's cancel, leaving L for the dimensions of each side.

- The equation is dimensionally correct.
- There are no dimensions for the constant.

Dimensional Analysis to Determine a Power Law

Determine powers in a proportionality

♣ Example: find the exponents in the expression $x \propto a^m t^n$

You must have lengths on both sides.

♣ Acceleration has dimensions of L/T^2

♣ Time has dimensions of T.

♣ Analysis gives $x \propto at^2$

Symbols

The symbol used in an equation is not necessarily the symbol used for its dimension.

- Some quantities have one symbol used consistently. For example, time is t virtually all the time.
- Some quantities have many symbols used, depending upon the specific situation. For example, lengths may be x, y, z, r, d, h, etc.

The dimensions will be given with a capitalized, non-italic letter. The algebraic symbol will be italicized.

Conversion of Units

When units are not consistent, you may need to convert to appropriate ones.

See Appendix A (for Serway's book) for an extensive list of conversion factors.

Units can be treated like algebraic quantities that can cancel each other out.

Ex: 1 minute= ? second

Order of Magnitude

- Approximation based on a number of assumptions
- May need to modify assumptions if more precise results are needed

The order of magnitude is the power of 10 that applies.

Order of Magnitude – Process

- Estimate a number and express it in scientific notation.
- The multiplier of the power of 10 needs to be between 1 and 10. Compare the multiplier to 3.162 ()
- If the remainder is less than 3.162, the order of magnitude is the power of 10 in the scientific notation.
- If the remainder is greater than 3.162, the order of magnitude is one more than the power of 10 in the scientific notation.

Using Order of Magnitude

- Estimating too high for one number is often canceled by estimating too low for another number.
- The resulting order of magnitude is generally reliable within about a factor of 10.

Working the problem allows you to drop digits, make reasonable approximations and simplify approximations.

With practice, your results will become better and better.

Uncertainty in Measurements

- There is uncertainty in every measurement – this uncertainty carries over through the calculations.
- ▪ May be due to the apparatus, the experimenter, and/or the number of measurements made
- ▪ 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. Zeros may or may not be significant.

- Those used to position the decimal point are not significant.
- To remove undertainty (ambiguity), use scientific notation. In a measurement, the significant figures include the first estimated digit.

Significant Figures, examples

0.0075 m has 2 significant figures

- The leading zeros are placeholders only.
- Write the value in scientific notation to show more clearly:

7.5×10^{-3} m for 2 significant figures

10.0 m has 3 significant figures

- The decimal point gives information about the reliability of the measurement.

1500 m is ambiguous

- Use 1.5×10^{3} m for 2 significant figures
- Use 1.50×10^{3} m for 3 significant figures
- Use 1.500×10^{3} m for 4 significant figures

Operations with Significant Figures – Multiplying or Dividing

- When multiplying or dividing several quantities, the number of significant figures in the final answer is the same as the number of significant figures in the quantity having the smallest number of significant figures.
- Example: 25.57 m x 2.45 m = 62.6 m^2
  - The 2.45 m limits your result to 3 significant figures.

Operations with Significant Figures – Adding or Subtracting

- When adding or subtracting, the number of decimal places in the result should equal the smallest number of decimal places in any term in the sum or difference.
- Example: 135 cm + 3.25 cm = 138 cm
  - The 135 cm limits your answer to the units decimal value.

Rounding

- Last retained digit is increased by 1 if the last digit dropped is greater than 5.
- Last retained digit remains as it is if the last digit dropped is less than 5.
- If the last digit dropped is equal to 5, the retained digit should be rounded to the nearest even number.
- Saving rounding until the final result will help eliminate accumulation of errors.
- It is useful to perform the solution in algebraic form and wait until the end to enter numerical values.
    - This saves keystrokes as well as minimizes rounding.