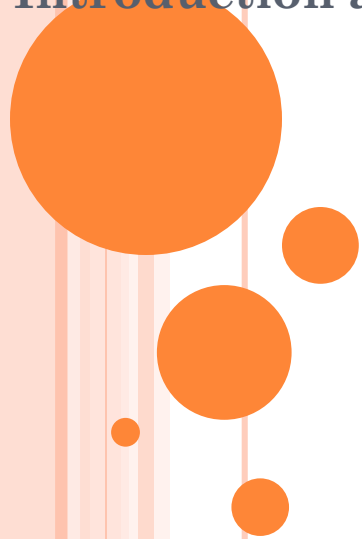


PHYSICS FOR SCIENTISTS AND ENGINEERS

Introduction and Chapter 1 – Physics and Measurements



QUANTITIES USED IN MECHANICS

In mechanics, three fundamental quantities are used:

Length •


Mass •

Time •

All other quantities in mechanics can be expressed in terms of the three fundamental quantities.




LENGTH

Length is the distance between two points in  space.

Units 

SI – meter, m •

Defined in terms of a meter – the distance  traveled by light in a vacuum during a given time

See Table 1.1 for some examples of lengths. 

MASS

Units ○

SI – kilogram, kg •

Defined in terms of a kilogram, based on a specific ○
cylinder kept at the International Bureau of
Standards

See Table 1.2 for masses of various objects. ○

TIME

Units ○


seconds, s •


Defined in terms of the oscillation of radiation ○
from a cesium atom

See Table 1.3 for some approximate time ○
intervals.



REASONABLENESS OF RESULTS

When solving a problem, you need to check your  answer to see if it seems reasonable.

Reviewing the tables of approximate values for  length, mass, and time will help you test for reasonableness.

US CUSTOMARY SYSTEM

Still used in the US, but text will use SI○

Quantity	Unit
Length	foot
Mass	slug
Time	second



FUNDAMENTAL AND DERIVED UNITS

Derived quantities can be expressed as a \circ mathematical combination of fundamental quantities.

Examples: \circ

Area •

A product of two lengths \circ

Speed •

A ratio of a length to a time interval \circ

Density •

A ratio of mass to volume \circ



MODEL BUILDING

A model is a system of physical components. ○

Useful when you cannot interact directly with the phenomenon ●

Identifies the physical components ●

Makes predictions about the behavior of the system ●

The predictions will be based on interactions among the components and/or ○

Based on the interactions between the components and the environment ○



BASIC QUANTITIES AND THEIR DIMENSION

Dimension has a specific meaning – it denotes the physical nature of a quantity. ○

Dimensions are often denoted with square brackets. ○

Length [L] •

Mass [M] •

Time [T] •

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, EXAMPLE

Given the equation: $x = \frac{1}{2} at^2$ ○

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 an extensive list of conversion 
factors.

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

CONVERSION

Always include units for every quantity, you can ○
carry the units through the entire calculation.

Will help detect possible errors •

Multiply original value by a ratio equal to one. ○

Example: ○

$$15.0 \text{ in} = ? \text{ cm}$$

$$15.0 \text{ in} \left(\frac{2.54 \text{ cm}}{1 \text{ in}} \right) = 38.1 \text{ cm}$$

Note the value inside the parentheses is equal to 1, •
since 1 inch is defined as 2.54 cm.