PHYSICS

Physics & Measurement

by

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Chapter Description

- Aims
  - Student can understand and apply appropriate unit in measurement, know how to use dimension analysis and can solve the physics problems related with unit conversion.

- Expected Outcomes
  - Should be able to use physical quantity and International systems of measurement.
  - Should be able to perform the dimensional analysis.
  - Should be able to solve problems involving unit conversion.

- References
  - Cutnell, J. D. and Johnson, K. W., 2010. Physics, 8th edition, Wiley, Asia.
  - Young, H. D. and Freedman, R. A., 2006. University Physics with Modern Physics. 12th edition, Pearson, San Francisco.
  - Giancoli, D. C., 2009. Physics for scientists and engineers: with modern Physics. Pearson Prentice Hall, United States of America.
  - Halliday, D. and Resnick, R., 2008. Fundamentals of Physics Extended. 8th edition. Wiley International Student Edition, Asia.

Content

- 1.1 Standard of length, mass and time
- 1.2 Dimension analysis
- 1.3 Conversion of unit

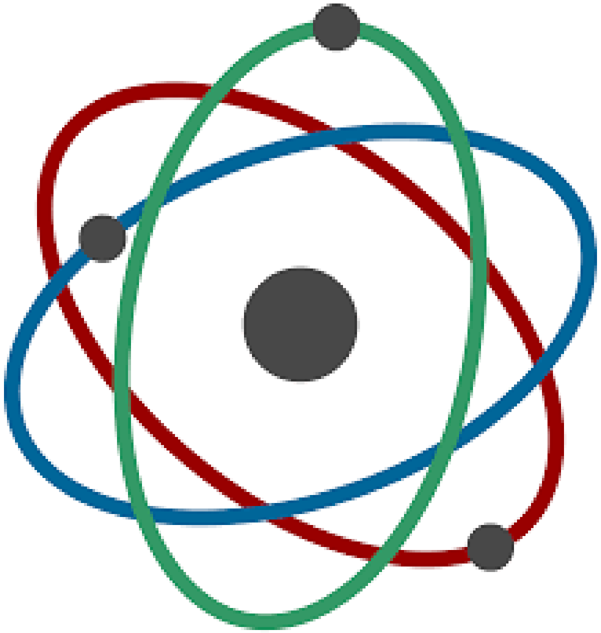
Physics

- **What is Physics**
  - – Greek word *phusika*, meaning *“of nature”*
  - – Physics is the systematic study of the way energy, matter and objects travels, changes and interacts.

Physics

- **Six major areas in Physics**

1. Classical Mechanics
2. Relativity
3. Optics
4. Thermodynamics
5. Electromagnetism
6. Quantum Mechanics



Physics

- **The important of Physics**

Fig.1 : Structure design

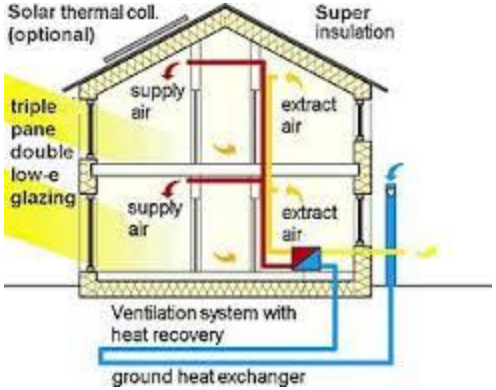


Fig. 2 : Heating System

Fig. 3 : Medical imaging systems

Standard of length, mass and time

- **Physical quantity**

→ can be expressed in any number (magnitude) to show physical phenomenon quantitatively

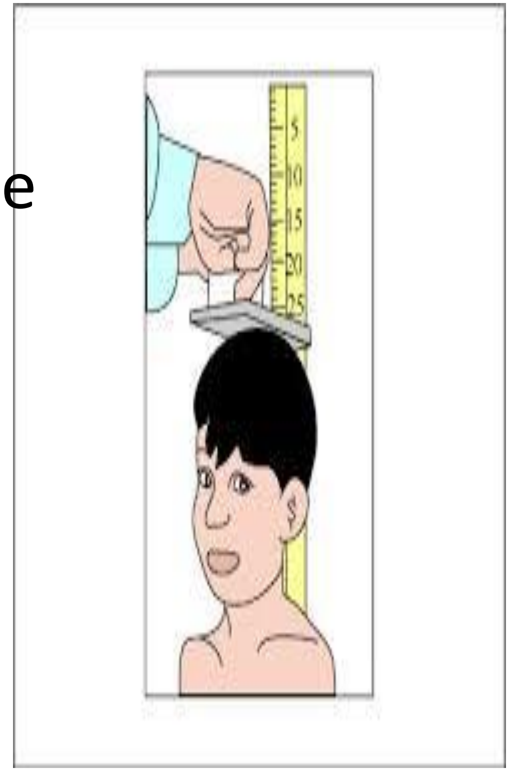
→ Unit is used as a standard for measurement of the same physical quantity

- → All physical quantities have:

  (*) a symbol

  (*) number value that shows magnitude

  (*) a unit of measurement



Example

Height of boy:

L = 1.40 m

symbol

number value

unit

Standard of length, mass and time

- **International system of units (S.I)**

→The most common unit used by engineers and scientists is International System of Units, SI Unit

→is normally called the “metric system”,

→since 1960, it is known as SI (abbreviation for its French name, *Système International*) or International System.

Quantity	SI Unit
Length	meter
Mass	kilogram
Time	second
Temperature	Kelvin
Electric Current	Ampere
Luminous Intensity	Candela
Amount of Substance	mole

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Standard of length, mass and time

- **Unit Prefix**

→ Prefixes correspond to powers of 10

→ Commonly wrote as a multiples of 10 or 1/10 in exponential notation:

$1000 = 10^3$, $1/1000 = 10^{-3}$

→ Each prefix

- *specific name*
- *specific abbreviation*
- used with any basic units
- multipliers of the basic unit

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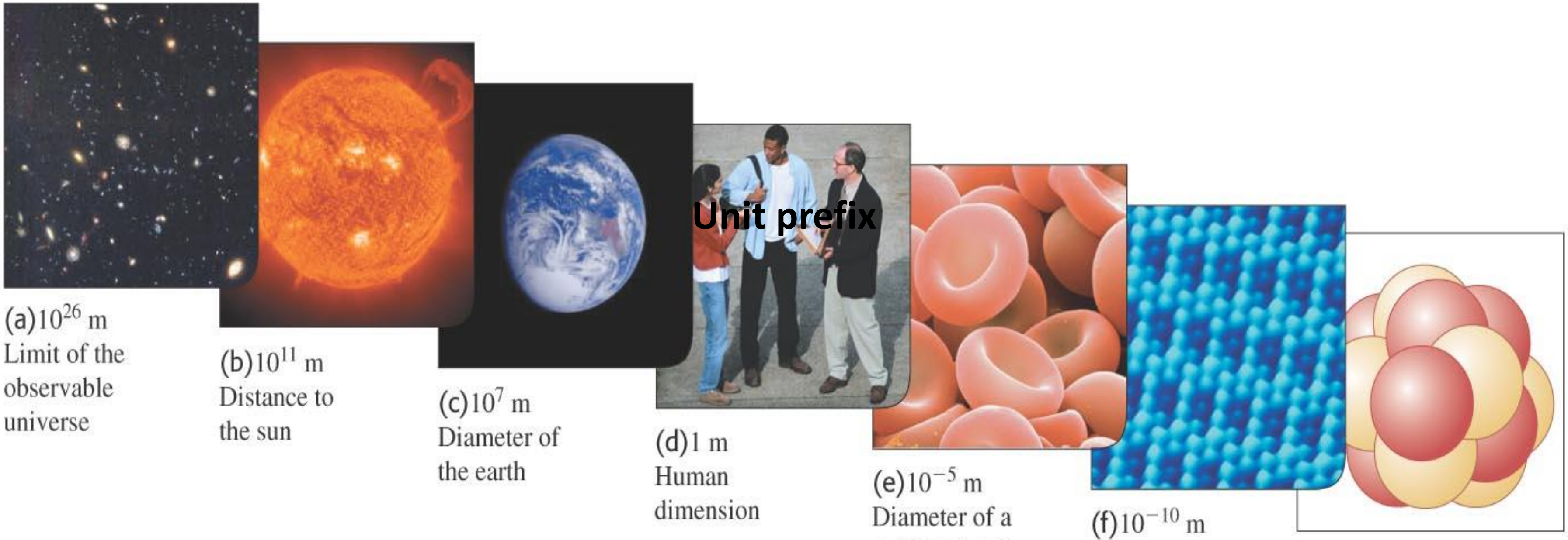
→ Unit prefixes size the unit to fit the situation.



Unit prefix

(a) 10^{26} m
Limit of the observable universe

(b) 10^{11} m
Distance to the sun

(c) 10^{7} m
Diameter of the earth

(d) 1 m
Human dimension

(e) 10^{-5} m
Diameter of a red blood cell

(f) 10^{-10} m
Radius of an atom

(g) 10^{-14} m
Radius of an atomic nucleus

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Standard of length, mass and time

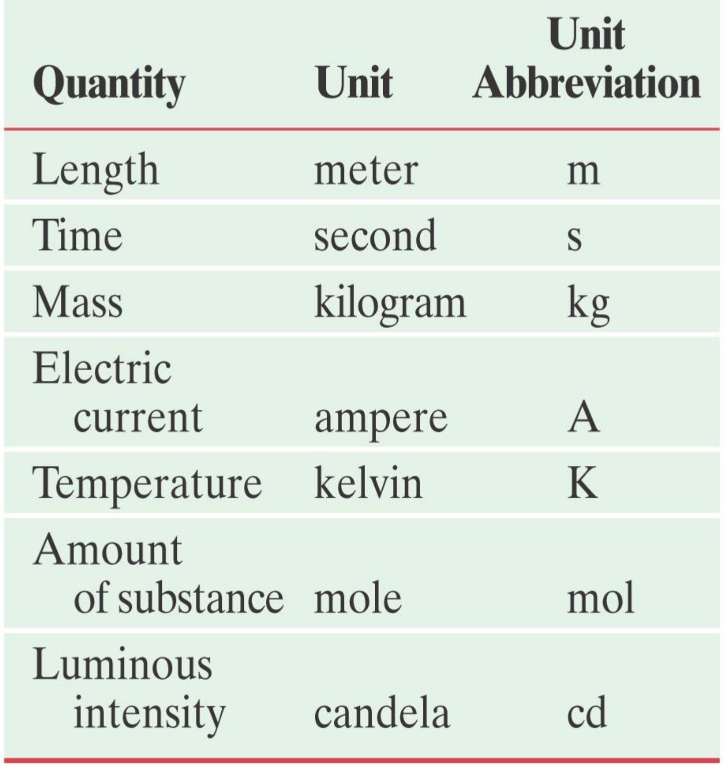
- **Base quantities**

→ In mechanics, 3 fundamental (*Basic*) quantities are used

i) Length

ii) Mass

iii) Time



Quantity	Unit	Unit Abbreviation
Length	meter	m
Time	second	s
Mass	kilogram	kg
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Base Quantity

- **i) Length**

→ is the distance between two points in space

→ SI Unit - meter, m

→ One meter is defined as the distance that light travels in a vacuum in 1/299,792,458 second.

Base Quantity

ii) Mass

→ Mass is how heavy something is without gravity

→ SI Unit – kilogram, kg

→ One kilogram (kg) is defined as the mass of a specific platinum–iridium alloy cylinder kept at the International Bureau of Weights and Measure , France.

Base Quantity

iii) Time

→ is a duration between two events

→ SI Unit - seconds, s

→ One second is defined as the time for a certain type electromagnetic wave emitted by cesium-133 atoms to undergo 9 192 631 770 wave cycles

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Standard of length, mass and time

- **Derived quantities**

→ are quantities from a combination of basic quantities

→ i.e : speed, acceleration, volume, density,

Dimensional Analysis

→ Is a method to analysis whether the equation is correct or incorrect or to help in deriving an equation

→ Square bracket is using to represent a dimension

- Time [T]
- Mass [M]
- Length [L]

→ Dimensions (time, mass, length, combinations) can be treated as algebraic quantities

- Divide, multiply, add, subtract

→ Any equation can be correct only if both sides of the equation have the same dimensions

Dimensional Analysis

→ There are no dimensions for constant

→ Each dimension can have many actual units

e.g.: dimension of area always $[L^2]$: the unit can be m^2, ft^2, cm^2 and so on.

→ The dimension can be same although the formula for a quantity is different

e.g. : area of circle is $\pi r^{2,}$ whereas area of a triangle is $A = ½\ bh$. Their dimensions are always $[L^2]$

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Example 1

→ Check the dimensions on each side for the equation $x = ½ at^{2}$

:

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

→ Thus, *LHS = RHS*

→ Hence, the equation is *dimensionally correct.*

Example 2

- Write down the basic dimensions of pressure,

pressure is defined as

$$p = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{[\mathrm{M}][L]\left[{}^{1}\!/_{T^2}\right]}{[L.L]}$$

$$= [\mathrm{M}]\left[L^{-1}\right]\left[T^{-2}\right]$$

Example 3

- Find the SI unit of DENSITY.

Density = mass / volume

$\rho = m / v$

$[\rho] = [M] / [L^3]$

$$\begin{tikzcd}[M] \arrow[d] & [L^3] \arrow[d] \\ (kg) & (m^3)\end{tikzcd}$$

$= \text{kg/m}^3$ @ kg m^{-3}

Conversion Unit

→ You must convert the units if the units are not consistent.

→ The units can cancel to each other (treated as algebraic quantities)

For example :

1 mile = 1.609 km =1609 m

1 ft = 30.48 cm = 0.304 m

1 m = 3.281 ft = 39.37 inch

1 in. = 2.45 cm = 0.0254 m

Conversion Unit

→ Every time, include units in your calculation for each physical quantity.

→ Multiply original value by a ratio equal to one

→ e.g.:- Express the length of 15.0 inch ruler in cm.

Given 1 inch = 2.54 cm

$$15.0\,in = ?\,cm$$

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

Example 4

→ What is the distance of the 1.00 mile travelling when it expressed in km

if 1 mile = 1609 m
1 km = 1000 m

Answer :- 1.61 km

Example 5

→ Given the density of lead is 11.3 g/cm^3 . Determine this value in kg/m^3

Convert the units from g to kg and from cm^3 to m^3.

1kg = 1000gm

1m = 100 cm

$$11.3\ \frac{\text{g}}{\text{cm}^3}\times\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right)\times\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^3=1.13\times10^4\ \frac{\text{kg}}{\text{m}^3}$$

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