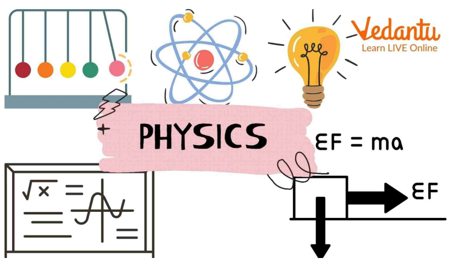
Earth sciences & petroleum department
1st Year
2nd Semester

General physics

Introduction – Physics and Measurements

Lect. No. 1

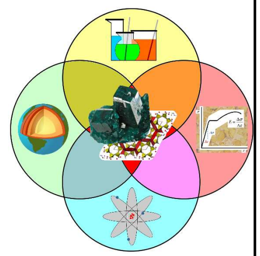


Lecturer
Sirwa Qader

Outline

- Introduction
- Physics
- Objectives of physics
- Model, Theory and Law
- Measurements
- Units of measurements
- Metric prefixes
- Basic quantities and their dimensions
- Dimensional analysis
- Units conversions

Introduction

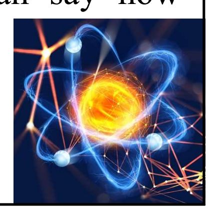


Geology is the study of the Earth in all its aspects except those that are now considered to be separate sciences of the Earth, like geophysics and meteorology.

It concerns the materials of which the Earth is made, and the processes that operate on them. Very many of these processes are physical, and their understanding involves an understanding of the underlying physics.

Physics

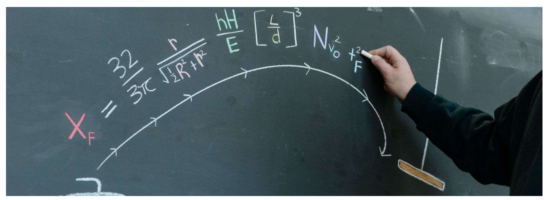
- Physics is the study of the rules (usually stated mathematically) by which the physical world operates.
- These rules describe "how" things happen. Laws of Nature
- These rules don't say "why" things happen. Physicists are most interested in being able to predict what will happen. Many physicists think that because they can say how things happen, they have answered the why.
- Physics deals with "how". "



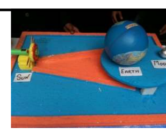
Objectives of Physics

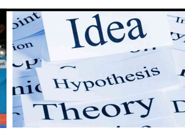
1. To find the limited number of fundamental laws that govern natural phenomena
2. To use these laws to develop theories that can predict the results of future experiments
3. Express the laws in the language of mathematics

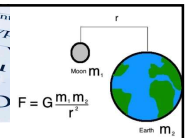
- Mathematics provides the bridge between theory and experiment.



Model, Theory, Law







Model

A representation of something that is often too difficult (or impossible) to display directly.
It is only accurate under limited situations.

Theory

an explanation for patterns in nature that is supported by scientific evidence and verified multiple times by various groups of researchers.

Law

Uses **concise language** to describe a **generalized pattern** in nature that is supported by scientific evidence and repeated experiments.
Often, a law can be expressed in the form of a single mathematical equation.

Measurements

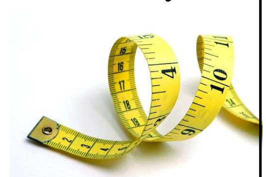
Used to describe natural phenomena

Each measurement is associated with a physical quantity

Need defined standards

Characteristics of standards for measurements:

- Readily accessible
- Possess some property that can be measured reliably
- Must yield the same results when used by anyone anywhere
- Cannot change with time



Units of measurement

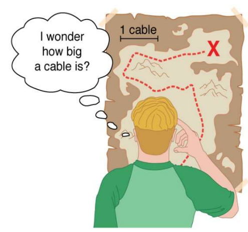
- Physics forms a link between the physical world (concepts) and the mathematical world (quantitative)
- We'll stick to MKS (SI) units in this course
  - –MKS: meters; kilograms; seconds
  - –As opposed to cgs: centimeter; gram; seconds

Physical quantity measured	Base unit	SI abbreviation
	mole	mol
	meter	m
	kilogram	kg
	second	s
	kelvin	K
	ampere	A
	candela	cd

Units

- USA uses English system as was used by the British Empire
- Rest of world uses SI system (International System or Metric System)
- Fundamental Units - Can only be defined by procedure to measure them.
    - Time = second (s)
    - Distance = meter (m)
    - Mass = kilogram (kg)
    - Electric Current = ampere (A)

- All other units are derived from these 4



Length

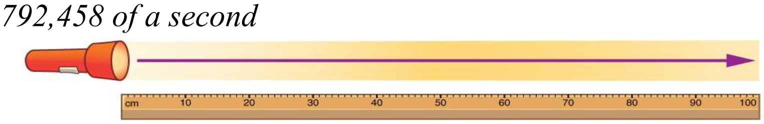
Length is the distance between two points in space.

Units

- SI – meter, m

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

Meter based on distance light travels in a vacuum in 1/299,792,458 of a second



Light travels a distance of 1 meter in 1/299,792,458 seconds

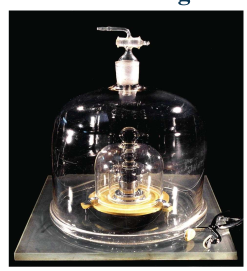
Mass

Units

- SI – kilogram, kg

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

Standard Kilogram



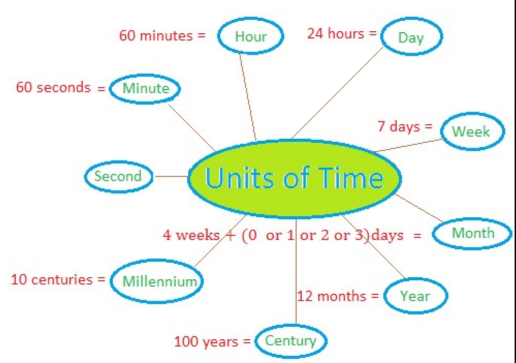
Mass based on mass of a platinum-iridium cylinder kept with the old meter standard at the International Bureau of Weights and Measures near Paris.

Time

Units

- seconds, s

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



Second based on time it takes for 9,192,631,770 vibrations of Cesium atoms

Secondary units

Units can be combined in a variety of ways to form complex units, many of which have their own names/symbols

Quantity	Formulation	Complex unit	For short
velocity	dist/time	m/s	—
acceleration	velocity/time	m/s^2 = m/s/s = m/s per s	—
force	F=ma	$kg \cdot m/s^2$	Newton (N)
work/energy	$W=F \cdot d$	$kg \cdot m^2/s^2$	Joule ($J = N \cdot m$)
power	energy/time	$kg \cdot m^2/s^3$	Watt (W = J/s)
frequency	cycles/second	1/s	Hertz (Hz)
pressure	force/area	$kg/m \cdot s^2$	Pascals (Pa = N/m^2)

Metric Prefixes

SI system based on powers of ten

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.

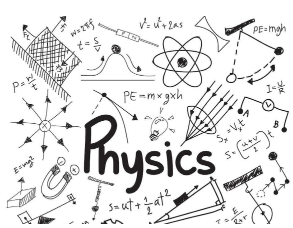
Prefix	Symbol	Value	Prefix	Symbol	Value
exa	E	10^{18}	**deci**	d	10^{-1}
peta	P	10^{15}	**centi**	c	10^{-2}
tera	T	10^{12}	**milli**	m	10^{-3}
giga	G	10^{9}	**micro**	µ	10^{-6}
mega	M	10^{6}	**nano**	n	10^{-9}
kilo	k	10^{3}	**pico**	p	10^{-12}
hecto	h	10^{2}	**femto**	f	10^{-15}
decka	da	10^{1}	**atto**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

Basic Quantities and Their Dimensions

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]



Fundamental and Derived Units

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

Examples:

- Area
  - A product of two lengths
- Speed
  - A ratio of a length to a time interval
- Density
  - A ratio of mass to volume

Dimensions and Units

Each dimension can have many actual units.

Table below shows for the dimensions and units of some derived quantities.

Dimensions and Some Units of Area, Volume, Velocity, and Acceleration

System	Area (L^2)	Volume (L^3)	Velocity (L/T)	Acceleration (L/T^2)
SI	m^2	m^3	m/s	m/s^2
cgs	cm^2	cm^3	cm/s	cm/s^2
U.S. customary	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: $x = ½ at^2$

Check dimensions on each side:

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

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

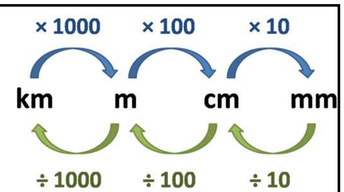
- Example: find the exponents in the expression

$$x = a^m t^n$$

- You must have lengths on both sides.
- Acceleration has dimensions of L/T^2
- Time has dimensions of T.
- Analysis gives

$$x = at^2$$

Units conversions



Multiply by conversion factors so that the unwanted unit cancels out.

Convert 20 Gm to m

$$\frac{20\ Gm}{} \cdot \left(\frac{1 \times 10^9\ m}{1\ Gm}\right)$$

$$2 \times 10^{10}\ m$$

Conversions

Convert 25 km/h to m/s

$$\frac{25\ km}{1\ h} \cdot \left(\frac{1 \times 10^3\ m}{1\ km}\right) \cdot \left(\frac{1\ h}{60\ min}\right) \cdot \left(\frac{1\ min}{60\ s}\right)$$

$$\frac{2.5 \times 10^4\ m}{3600\ s}$$

$$6.94\ m/s$$

Thank you