VESP Vision

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Program Code:-Common to all 1st semester

Course Name:-Basic Science(Physics)

Course Code : - 22102

Course coordinator: Mrs. Deepa Gupte

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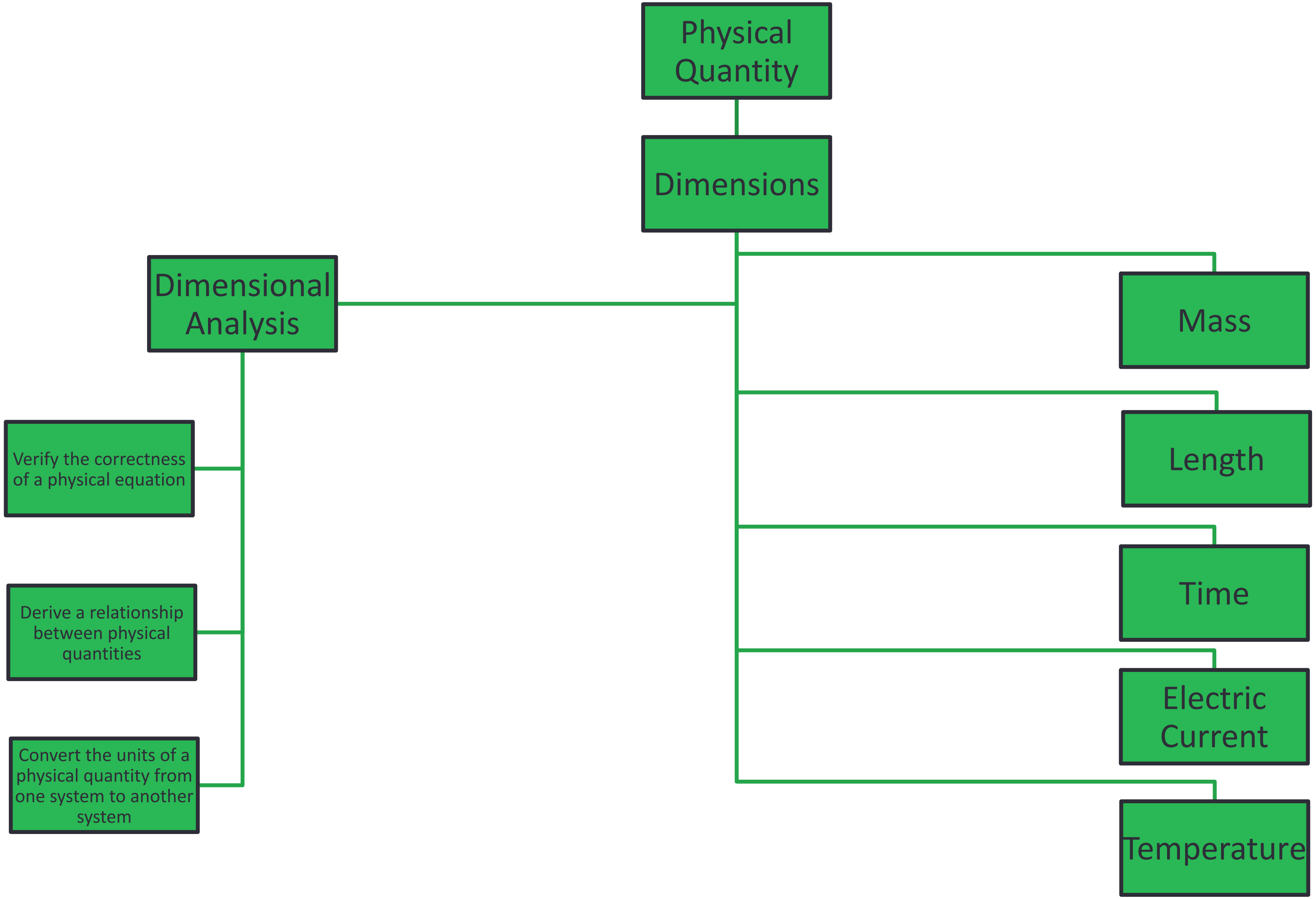
Unit No:1
Unit Name: Units and Measurements

Unit Outcomes (UO1d): Describe the procedure to determine the dimensions of the given physical quantities
Learning Outcome (LO5) : Students will be able to determine the dimensions of various physical quantities
Contents: Dimensions & Dimensional Formula

Concept Map


Physical Quantity
Dimensions
Dimensional Analysis
Verify the correctness of a physical equation
Derive a relationship between physical quantities
Convert the units of a physical quantity from one system to another system
Mass
Length
Time
Electric Current
Temperature

Learning Objective/ Key learning

- Students will be able to determine the dimensions of various physical quantities .
- Students will be able to state uses of dimensional analysis.

Dimension & Dimensional Formula

- **Dimensions** of a physical quantity are the powers to which the fundamental quantities must be raised to represent the given physical quantity.
- Illustration :
- The area is the product of two lengths.
  Area = Length X breadth = [L] x [L] = [L^2]
  Therefore, [A] = [L^2]
- Hence the dimensions of area are, 0 in mass, 2 in length, and 0 in time
- **DIMENSIONAL FORMULA** The expression which shows how and which of the quantities represent the dimensions of a particular physical quantity is called the dimensional formula of the given physical quantity. FOR EXAMPLE: The dimensional formula of the given physical quantity, area is [$M^0L^2T^0$]

DIMENSIONAL EQUATION An equation obtained by equating a physical quantity with its dimensional formula is called dimensional equation of the physical quantity

FOR EXAMPLE:

[area]= [$M^0L^2T^0$]

Dimensions

Sr. No.	Fundamental Quantity	Dimensional Symbol
1.	Length	L
2.	Mass	M
3.	Time	T

Sr. No	Physical Quantity	Formula	Dimensions	Dimensional Formula	S.I unit
1.	Area	$A = L\ x\ B$	$L \times L = L^2$	$[M^0L^2T^0]$	m^2
2.	Volume	$V = L\ x\ B\ x\ H$	$L \times L \times L = L^3$	$[M^0L^3T^0]$	m^3
3.	Density	$d = m/v$	M/L^3	$[M^1L^{-3}T^0]$	kg/m^3
4.	Speed or velocity	$v = s/t$	L/T	$[M^0L^1T^{-1}]$	m/s
5.	Acceleration		$\frac{L/T}{T} = \frac{L}{T^2}$	$[M^0L^1T^{-2}]$	m/s^2
6.	Momentum	$\varrho = M\ x\ V$	M x (L/T)	$[M^1L^1T^{-1}]$	kg-m/s

EXAMPLE DIMENSIONAL FORMULA

Sr. No.	Physical Quantity	Formula	Dimensions	Dimensional Formula	S.I unit
7.	Force			$[M^1L^1T^{-2}]$	N or kg-m/s^2
8.	Impulse	$I = F\,x\,t$		$[M^1L^1T^{-1}]$	N-s
9.	Work	$W = F\,x\,s$		$[M^1L^2T^{-2}]$	J or N-m
10.	Energy	$K.E=(1/2)mv^2$ $P.E=mgh$		$[M^1L^2T^{-2}]$	J or N-m
11.	Power	$P=W/t$		$[M^1L^2T^{-3}]$	J/s or watt
12.	Pressure or Stress	$P=F/A$		$[M^1L^{-1}T^{-2}]$	Pascal or N/m^2

Dimensional formulae for Physical Quantities in Electricity

	Physical quantity	Symbol	Formula	Dimensional formula	Unit
Electricity	Electric current	I	Fundamental	$[M^0L^0T^0I^1]$	Ampere (A)
	Electric charge	Q	Current x time	$[M^0L^0T^1 I^1]$	Coulomb or A s
	Intensity of electric field	E	Force / charge	$[M^1LT^{-3}I^{-1}]$	N C^{-1} or V m^{-1}
	Potential difference	E	Work / charge	$[M^1L^2T^{-3}I^{-1}]$	volt (V)
	Electric resistance	R	Voltage / current	$[M^1L^2T^{-3}I^{-2}]$	Ohm(Ω)
	Electric conductance	G	1 / resistance	$[M^{-1}L^{-2}T^3I^2]$	Ohm^{-1} or mho or S
	Specific resistance	ρ	ρ = RA/l	$[M^1L^3T^{-3}I^{-2}]$	m
	Conductivity	σ	1 / specific Resistance	$[M^{-1}L^{-3}T^3I^2]$	S/m or S m^{-1}
	Electric capacitance	C	Charge / potential	$[M^{-1}L^{-2}T^4I^2]$	C V^{-1} or farad
	Permittivity of free space	ε_0	$Q_1Q_2/4\pi Fd^2$	$[M^{-1}L^{-3}T^4I^2]$	$C^2 N^{-1}m^{-2}$

Dimensional formulae for Physical Quantities in Magnetism

Physical quantity	Symbol	Formula	Dimensional formula	Unit
Magnetic pole strength	m	m = M / l	$[M^0LT^0I^1]$	A m
Magnetic dipole moment	M	Pole strength x dipole length	$[M^0L^2T^0I^1]$	A m^2
Permeability of free space	μ_0		$[M^1LT^{-2}I^{-2}]$	H m^{-1} or N A^{-2}
Intensity of magnetization, magnetic field strength, magnetic intensity, magnetic moment density	I	Magnetic moment / Volume	$M^0L^{-1}T^0I^1]$	A m^{-1}
Magnetic flux	Φ_b	Magnetic induction x area	$[M^1L^2T^{-2}I^{-1}]$	weber (Wb)
Magnetic induction, magnetic flux density, magnetic field	B	Force/(current x length)	$[M^1L^0T^{-2}I^{-1}]$	N A^{-1} m^{-1} or tesla (T)
Inductance or coefficient of self induction	L	$L = 2E/(LI^2)$	$[M^1L^2T^{-2}I^{-2}]$	henry (H)

Quantities with same dimensional formulae

1. Impulse and momentum $[M^{1} L^{1} T^{-1}]$
2. Work, energy, torque, moment of force $[M^{1} L^{2} T^{-2}]$
3. Stress, pressure, modulus of elasticity, energy density $[M^{1} L^{-1} T^{-2}]$
4. surface tension, surface energy $[M^{1} L^{0} T^{-2}]$
5. Angular velocity, frequency, velocity gradient $[M^{0} L^{0} T^{-1}]$
6. Force, Weight $[M^{1} L^{1} T^{-2}]$

Attempt Set 1 MCQs

Set 1: Question No 1	Set 1: Question No 2	Set 1: Question No 3
The dimensional formula of speed is ____________.	$[L^{2} M^{1} T^{-2}]$ is the dimensional formula of ________________ .	The dimensional formula of power is ____________.
Recall/ Remembering	Understanding	Application
a) $[L^{1} M^{0} T^{-1}]$	a) energy	a) $[L^{1} M^{1} T^{-1}]$
b) $[L^{1} M^{-1} T^{0}]$	b) Heat	b) $[L^{2} M^{1} T^{-2}]$
a) $[L^{0} M^{1} T^{1}]$	c) work	c) $[L^{2} M^{1} T^{-3}]$
b) $[L^{-1} M^{1} T^{1}]$	d) all of the above	d) $[L^{0} M^{1} T^{-2}]$
Ans: <a>	**Ans: <d>**	**Ans: <c>**

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Dimensional Analysis

- The study of the relationship between physical quantities with the help of dimensions and units of measurement is termed as dimensional analysis.

- The Dimensional analysis are used to:
- Verify the correctness of a physical equation,
- Derive a relationship between physical quantities
- Converting the units of a physical quantity from one system to another system.

To verify the correctness of a physical equation

- The equation is $v^2 = u^2 + 2as$
- Remember Each term on both sides of the equation must have the same dimensions
- The dimensions of LHS are $[M^0L^1 T^{-1}]^2 = [M^0L^2 T^{-2}]$
- The dimensions of RHS are $= [M^0L^2 T^{-2}] + [M^0L^2 T^{-2}]$
- The dimensions of LHS and RHS are the same and hence the equation is dimensionally correct.
- As in the above equation dimensions of each term on both sides are same, so this equation is dimensionally correct.

To convert the units of a physical quantity from one system to another system.

The numerical value of a physical quantity in a system of units can be changed to another system of units using the equation nu = constant,

where n is the numerical value and u is the dimensional value in that system of unit.

The measure of a physical quantity i.e. Q = nu = constant

$n_1 u_1 = n_2 u_2$

$n_1[u_1] = n_2 [u_2]$

$n1[M_1^a L_1^b T_1^c] = n_2[M_2^a L_2^b T_2^c]$

$: n_2 = n_1 [M_{1/} M_2]^a [L_1/L_2]^b [T_1/T_2]^c$

To convert the units of a physical quantity from one system to another system.

- Convert force of unit newton into dyne.

We know that, newton is the S.I. unit (first system) and dyne is the CGS unit (second system) of force and dimensional formula of force is $[M^1 L^1 T^{-2}]$

- $a = 1$, $b = 1$, $c = -2$
- First system(SI system)
- $M_1 = 1\text{kg}$ $L_1 = 1\text{ m}$ $T_1 = 1\text{ sec}$ $n_1 = 1$
- Second system (CGS system)
- $M_2 = 1\text{g}$ $L_2 = 1\text{ cm}$ $T_2 = 1\text{ sec}$ n_2 = to be calculated
- By using: $n_2 = n_1 [M_1/M_2]^a [L_1/L_2]^b [T_1/T_2]^c$
- $n_2 = 1 [\text{kg}/\text{gm}]^1 [\text{m}/\text{cm}]^1 [\text{sec}/\text{sec}]^{-2}$
- $n_2 = 1 [10^3 \text{gm}/\text{gm}]^1 [10^2 \text{cm}/\text{cm}]^1 [\text{sec}/\text{sec}]^{-2}$
- $n_2 = 10^5$

Attempt Set 2 MCQs

Set 2: Question No 1	Set 2: Question No 2	Set 2: Question No 3
If $[L^a M^b T^c]$ is the dimensional formula for force, then find the value of 2a -b -c.	The dimensional formula for impulse is the same as dimensional formula for ____________.	$[L^1 M^0 T^{-2}]$ is the dimensional formula of _______________ .
Recall/ Remembering	Understanding	Application
a) 3	a) acceleration	a) energy
b) -4	b) force	b) Heat
c) 6	c) momentum	c) work
d) 8	d) power	d) force
Ans: <a>	**Ans: <c>**	**Ans: <d>**

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