

CHAPTER 1

MEASUREMENTS



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Example

Describe physical quantity

Temperature $T = 30$ degrees Celsius:

30 is numerical value

'degree Celsius' is the unit.

Remark1

Scientific Notation

$$a \times 10^b$$

$1 \leq |a| < 10$ (red text, arrow pointing to a)

$b \leftarrow$ integer (blue text, arrow pointing to b)

A base of 10. (green text, arrow pointing to 10)

Convert to Scientific Notation

3.250,000,000

9 units
to the LEFT

LEFT $\rightarrow$ positive
exponent

$$3.25 \times 10^9$$

0.00000004

7 units
to the RIGHT

RIGHT $\rightarrow$ negative
exponent

$$4 \times 10^{-7}$$

Example: write the following numbers using scientific notation

➤ *Positive powers*

1) $125000 = 1.25 \times 10^5$

2) $31400000 = 3.14 \times 10^7$

3) $25223 = 2.5 \times 10^4$

➤ *Negative powers*

1) $0.0000551 = 5.5 \times 10^{-5}$

2) $0.00000983 = 9.8 \times 10^{-6}$

3) $0.0001791 = 1.79 \times 10^{-4}$

2) PHYSICAL QUANTITIES

- ANY PHYSICAL QUANTITY MUST BE MEASURABLE
- Physical quantities have numerical value and unit of measurement.
- EVERY PHYSICAL QUANTITY HAS A UNIQUE UNIT

3) Fundamental Quantities and Their S.I Units

Quantity	Unit	Symbol	Dimension
Length	Meter	m	L
Mass	Kilogram	Kg	M
Time	Second	s	T
Electric current	Ampere	A	I
Temperature	Kelvin	K	-
Amount of substance	Mole	mol	-
Luminous intensity	Candela	cd	-

Remark 2: Quantities we used mostly

Four fundamental quantities are used:

- LENGTH → L
- MASS → M
- TIME → T
- Electric current → I

All other quantities can be expressed in terms of the four fundamental quantities

4) Dimensions And Units

Quantity	Area (A)	Volume (V)	Speed (v)	Acceleration (a)
SI Units	m^2	m^3	m/s or $m \cdot s^{-1}$	m/s^2 or $m \cdot s^{-2}$
Dimensions	L^2	L^3	L/T or $L \cdot T^{-1}$	L/T^2 or $L \cdot T^{-2}$

5) Derived Quantities

<i>Derived Quantities</i>	<i>Symbol</i>	<i>Relationship with base quantities</i>	<i>Derived units (S.I)</i>	<i>Dimension</i>
Area	A	$Length \times Length$	m^2	L^2
Volume	V	$Length \times Length \times Length$	m^3	L^3
Density	ρ	$\frac{Mass}{Length \times Length \times Length}$	$Kg.m^{-3}$	$M.L^{-3}$
Velocity	v	$\frac{Displacement}{Time}$	$m.s^{-1}$	$L.T^{-1}$
Acceleration	a	$\frac{Velocity}{Time}$	$m.s^{-2}$	$L.T^{-2}$

<i>Derived Quantities</i>	<i>Symbol</i>	<i>Relationship with base quantities</i>	<i>Derived units (S.I)</i>	<i>Dimension</i>
Force	F	$Mass \times Acceleration$	N	$M.L.T^{-2}$
Work	W	$Force \times Displacement$	J	$M.L^2.T^{-2}$
Energy	E_K	$\frac{1}{2} \times Mass \times Velocity \times Velocity$	J	$M.L^2.T^{-2}$
	E_P	$Mass \times Gravity \times Height$		
Power	P	$\frac{Force \times Displacement}{Time}$	W	$M.L^2.T^{-3}$
Pressure	p	$\frac{Force}{Area}$	Pa	$M.L^{-1}.T^{-2}$

<i>Derived Quantities</i>	<i>Symbol</i>	<i>Relationship with base quantities</i>	<i>Derived units (S.I)</i>	<i>Dimension</i>
Charge	q	$Current \times Time$	C	$I.T$
Electric field	E	$\frac{Force}{Charge}$	$N.C^{-1}$	$M.L.I^{-1}.T^{-3}$
Electric potential	V	$Electric\ field \times Distance$	V	$M.L^2.I^{-1}.T^{-3}$
Capacitance	C	$\frac{Charge}{Potential}$	F	$I^2.T^4.M^{-1}.L^{-2}$

Example : The Kinetic Energy (K.E) can be calculated according to the formula:

$$K.E = \frac{P^2}{2m}$$

where P = The Momentum , m = Mass.
Find The Unit and dimension of P ?

$$K.E = \frac{P^2}{2m} \rightarrow P^2 = 2 \times m \times K.E$$

$$[P^2] \equiv Kg \times Kg.m^2.S^{-2}$$

$$[P^2] \equiv Kg^2.m^2.S^{-2}$$

$$\therefore \text{unit of } [P] \equiv kg.m.S^{-1}$$

$$\therefore \text{dim of } [P] \equiv M.L.T^{-1}$$

6) Prefix for powers of TEN

Power	Prefix	Abbreviation
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d

Power	Prefix	Abbreviation
10^1	deca	da
10^2	hecto	h
10^3	Kilo	K
10^6	Mega	M
10^9	Giga	G
10^{12}	Tera	T
10^{15}	Peta	P

- Prefixes are used in physics together with units
- Other Sciences are used prefixes like computer Science and biology

Example: write the following quantity using a proper prefix

$$1) F = 2 \times 10^3 N \rightarrow 2KN$$

$$2) L = 6 \times 10^{-6} m \rightarrow 6\mu m$$

$$3) P = 90 \times 10^8 Pa \rightarrow 9 \times 10^9 Pa \rightarrow 9GPa$$

$$4) C = 75 \times 10^{-7} F \rightarrow 7.5 \times 10^{-6} F \rightarrow 7.5\mu F$$

$$5) A = 10 \times 10^5 m^2 \rightarrow 1 \times 10^6 m^2 \rightarrow 1 \times (10^3)^2 m^2 \rightarrow 1 Km^2$$

$$6) T^3 = 25 \times 10^{-10} s^3 \rightarrow 2.5 \times 10^{-9} s^3 \rightarrow 2.5 \times (10^{-3})^3 s^3 \rightarrow 2.5 ms^3$$

$$7) M^2 = 50 \times 10^{-31} g^2 \rightarrow 5 \times 10^{-30} g^2 \rightarrow 5 \times (10^{-15})^2 g^2 \rightarrow 5 fg^2$$

7- Conversion of units

- ❖ Measurements in physics must be in international units
- ❖ There is a difference between the units of measurement in physics and the units of measurement in public life
- ❖ Countries use different units of measurement
- ❖ Sometimes it is necessary to convert units from one measurement system to another, or to convert within a system
- ❖ Units can be treated as algebraic quantities that can cancel each other

7- Conversion of units

➤ Some conversion factor

$$1 \text{ h} = 60 \text{ min} , 1 \text{ min} = 60 \text{ s} , 1 \text{ h} = 3600 \text{ s}$$

$$1 \text{ m} = 3.281 \text{ ft} , 1 \text{ ft} = 0.3048 \text{ m}$$

$$1 \text{ in} = 2.54 \text{ cm} , 1 \text{ cm} = 0.393 \text{ in}$$

$$1 \text{ mil} = 1609 \text{ m} , 1 \text{ mil} = 1.609 \text{ Km}$$

➤ Prefixes conversion

From bigger to smaller multiply by 10^n , $n = 1, 2, 3, 4, \dots$

From smaller to bigger multiply by 10^{-n} , $n = 1, 2, 3, 4, \dots$

Example : convert the following quantities

$$1) \quad L = 6 \text{ cm} \rightarrow ?? \text{ m} \leftrightarrow 6 \text{ cm} \rightarrow 6 \times 10^{-2} \text{ m}$$

$$2) \quad T = 9 \text{ ns} \rightarrow ?? \text{ s} \leftrightarrow 9 \text{ ns} \rightarrow 9 \times 10^{-9} \text{ s}$$

$$3) \quad M = 5 \text{ Mg} \rightarrow ?? \text{ kg} \leftrightarrow 5 \text{ Mg} \rightarrow 5 \times 10^3 \text{ Kg}$$

$$4) \quad A = 75 \text{ mm}^2 \rightarrow ?? \text{ m}^2 \leftrightarrow 75 \text{ mm}^2 \rightarrow 75 \times (10^{-3})^2 \text{ m}^2 \rightarrow 75 \times 10^{-6} \text{ m}^2$$

$$5) \quad V = 25 \text{ Gm}^3 \rightarrow ?? \text{ m}^3 \leftrightarrow 25 \text{ Gm}^3 \rightarrow 25 \times (10^9)^3 \text{ m}^3 \rightarrow 25 \times 10^{27} \text{ m}^3$$

$$6) \quad L = 20 \text{ ft} \rightarrow ?? \text{ m} \leftrightarrow 20 \cancel{\text{ft}} \times \frac{0.3048 \text{ m}}{1 \cancel{\text{ft}}} \rightarrow 6.1 \text{ m}$$

$$7) \quad V = 35 \text{ in}^3 \rightarrow ?? \text{ cm}^3 \leftrightarrow 35 \cancel{\text{in}^3} \times \frac{2.54^3 \text{ cm}^3}{1 \cancel{\text{in}^3}} \rightarrow 573.5 \text{ cm}^3$$

$$8) \quad v = 120 \text{ Km/h} \rightarrow ?? \text{ m/s} \leftrightarrow 120 \frac{\cancel{\text{Km}}}{\cancel{\text{h}}} \times \frac{10^3 \cancel{\text{m}}}{1 \cancel{\text{Km}}} \times \frac{1 \cancel{\text{h}}}{3600 \text{ s}} \rightarrow 33.3 \text{ m/s}$$

$$9) \quad v = 120 \text{ mile/h} \rightarrow ?? \text{ Km/h} \leftrightarrow 120 \frac{\cancel{\text{mile}}}{\cancel{\text{h}}} \times \frac{1.609 \cancel{\text{km}}}{1 \cancel{\text{mile}}} \rightarrow 193.1 \text{ Km/h}$$

$$10) \quad a = 120 \text{ Km/h}^2 \rightarrow ?? \text{ m/s}^2 \leftrightarrow 120 \frac{\cancel{\text{Km}}}{\cancel{\text{h}^2}} \times \frac{10^3 \cancel{\text{m}}}{1 \cancel{\text{Km}}} \times \frac{1 \cancel{\text{h}^2}}{3600^2 \text{ s}^2} \rightarrow 9.3 * 10^{-3} \text{ m/s}^2$$

8- Areas and Volumes

- ☐ In physics, sometimes we need to calculate the area or volume of some geometric shapes
- ☐ Every geometric figure has a special formula for calculating its area or volume
- ☐ The formula of areas and volumes for the required geometric shapes are given on an external worksheet

Example : find a volume and curved surface area for right circular cylinder with a radius of $r = 45 \text{ cm}$ and a height of $h = 2.4 \text{ m}$

$$V_{cylinder} = \pi r^2 h = \pi (45 \times 10^{-2})^2 \times 2.4$$

$$\therefore V_{cylinder} = 1.5 \text{ m}^3$$

$$A_{curved surface} = 2\pi r h = 2\pi \times 45 \times 10^{-2} \times 2.4 =$$

$$\therefore A_{curved surface} = 6.8 \text{ m}^2$$

Example : A sphere has a volume of 400 ft^3 , find the radius of the sphere (in m) { $1 \text{ ft} = 0.3048 \text{ m}$ }

$$r = \sqrt[3]{\frac{3V}{4\pi}} = \sqrt[3]{\frac{3 \times 400}{4\pi}} = 4.6 \text{ ft}$$

$$r = 4.57 \cancel{\text{ ft}} \times \frac{0.3048 \text{ m}}{1 \cancel{\text{ ft}}} = 1.4 \text{ m}$$

Exercises : Choose the correct answer :

1) The prefix Tera equals

A	B	C	D	E
10^{-3}	10^{-12}	10^{12}	10^9	None of them

2) The prefix femto equals

A	B	C	D	E
10^{-9}	10^{-12}	10^9	10^{-3}	None of them

3) The Dimensions of Density is

A	B	C	D	E
$M.L^{-1}$	$M.L^{-3}$	$M.T.L$	$L.M^{-3}$	None of them

4) In scientific notation, 39432 is written as

A	B	C	D	E
3.90×10^4	3.90×10^{-4}	0.39×10^4	0.39×10^{-3}	None of them

4) The dimensions of Charge is

A	B	C	D	E
$M.T^{-1}$	$T.I^{-1}$	$I.T$	$I^{-1}T^{-1}$	None of them

5) In scientific notation, 0.0012 is written as

A	B	C	D	E
12×10^3	1.2×10^3	0.12×10^{-3}	1.2×10^{-3}	None of them

6) The unit for length is

A	B	C	D	E
meter	inch	feet	mile	All of them

7) Using a proper prefix , the quantity $T^2 = 600 \times 10^{-8}S^2$ can be written as

A	B	C	D	E
$6\mu s^2$	$600ns^2$	$6ms^2$	$0.6ps^2$	None of them

8) A quantity has a unit of $Kg.m^{-1}.s^{-2}$,then its dimension is

A	B	C	D	E
$M.L^{-1}.T^{-2}$	$M.L^{-1}.T^{-1}$	$M.L.T^{-2}$	$M.L^{-1}.T$	None of them

9) A cone has a radius of 50 cm , a height of 30 cm and a mass of 30 kg. the mass density of the cone (in Kg/m^3) is

A	B	C	D	E
127	1200	382	832	None of them

10) A Sphere with a radius of 19.68 ft has a volume of (in m^3) , {1 m = 3.28 ft}

A	B	C	D	E
882π	27π	48π	288π	None of them

11) A train moves at speed 370 Km/h , then the speed of the train in mile/h is , {1 mile = 1.609 Km}

A	B	C	D	E
595	230	320	370	None of them