Unit and Measurement

The comparison of any physical quantity with its standard unit is called Measurement.

Physical Quantities

All the quantities in term of which laws of physics are described, and whose measurment is necessary are called physical quantities

Units

- A definite amount of a physical quantity is taken as its standard unit.

- The standard unit should be easily ~~res~~ reproducible internationally accepted

Fundamental Units

Those physical quantities which are independent to each other are called fundamental quantities and their units are called fundamental units.

1.	Length	metre	m
2.	Mass	Kilogram	Kg
3.	time	second	S
4.	Temperature	kelvin	K
5	Electric current	ampere	A
6	Luminous intensity	Candela	cd
7.	Amount of substance	mole	mol

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Supplementary fundamental units

Radian and steradian are two supplementary units. It measures plane ~~agl~~ angle and Solid angle ~~r~~ respectively

Derived unit Quantity

These type of Quantity / Quantities depends on some fundamental quantity

e.g Velocity, acceleration, force, work

~~Definitions of fundamental Quantities~~

1. ~~1~~ Kilogram:

Supplementary Quantities

1. Plane angle radian rad.
2. ~~Solid angle~~

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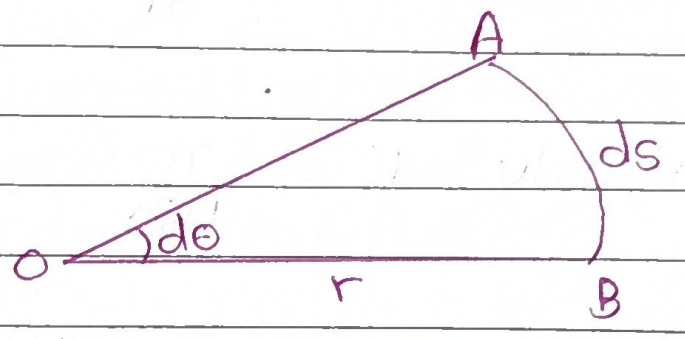
Supplementary Quantities

i) Plane angle ($d\theta$): This is the ratio of the length of an arc of a circle to the radius of the circle

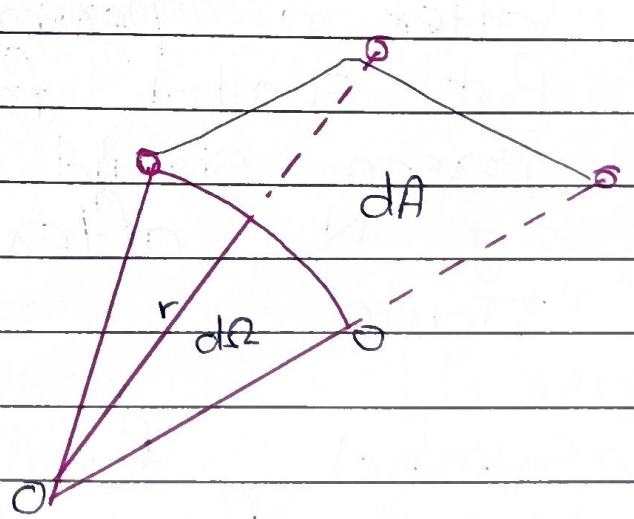
$$d\theta = \frac{ds}{r}$$



It is measured in radian (rad)
An angle θ in radian is denoted as θ^c

ii) Solid angle ($d\Omega$): This is the 3-dimensional analogue of $d\theta$ and is defined as the area of a portion of surface of a spehere to the square of radius of the ~~spl~~ sphere.

$$d\Omega = \frac{dA}{r^2}$$



It is measured in steradian (Sr
A shpere of radius r has surface area $4\pi r^2$.
entire sphere at its centre is $\Omega = \frac{4\pi r^2}{r^2} = 4\pi$ Sr

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The relation between radian and degree is

π radian

$\pi^c = 180^\circ$

1 radian $= \frac{180}{\pi} = \frac{180}{3.1415} = 57.97^\circ$

Similarly $1' = \frac{\pi}{180} = \frac{3.14}{180} = 1.745 \times 10^{-2}$ rad

$1^\circ = 60'$ $\quad 1' = 2.91 \times 10^{-4}$ rad

Conventions for the use of SI units

1. Unit of every physical quantity should be ~~res~~ represented by its symbol

2. full name of a unit always starts with with smaller letter even if the name is after a person e.g 1 newton, 1 joule But symbol for unit named after a person should be in capital letter e.g N after scientist Newton, J after Joule

3. Symbol for unit do not take plural from for example, force of 20N and not 20 newtons or not 20Ns

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4. A Prefix symbol is used before the Symbol of the unit.
Thus prefix symbol and units symbol Constitute a new symbol for the unit which can be raised to a positive or negative power of 10

* 1 ms = 1 millisecond = 10^{-3} s
* 1 μs = 1 microsecond = 10^{-6} s
* 1 ns = 1 nanosecond = 10^{-9} s

use of double prefixes is avoided when single prefix is available.

10^{-6} s = 1 μs and not 1 mms
10^{-9} s = 1 ns and not 1 mμs

Measurment of length

Measurement	Length in met
Distance to Andromeda Galaxy (from Earth)	2×10^{22} m
Distance to nearest star (after sun) Proxima Centuari (from earth)	4×10^{16} m
Distance to pluto (from earth)	6×10^{12} m
Average Radius of Earth	6×10^{6} m
Height of mount Everest	9×10^{3} m
Thickness of this paper	1×10^{-4} m
Length of a typical virus	1×10^{-8} m
Radius of hydrogen atom	5×10^{-11} m
Radius of proton	1×10^{-15} m

Dimension of Physical quantity

The dimensions of a physical quantity are the power to which the concerned fundamental units must be raised in order to obtain the unit of the given physical quantity

Length → L
mass → M
time → T
Current → A
temp → K
mious → di
amount → Mo

Note: If any physical quantity is ratio of same dimension, quantity will be dimensionless e.g. angle

* There are many physical quantites which have same dimension, angle, Torque, Strain, work.

* All the pure numbers are dimensionless

* CR, $\frac{L}{R}$, $\sqrt{LC}$ all have dimension of time

* Exponent (e^x), logx and trignometric

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Principle of Homogemeity of Dimensions

According to this principle all the term of the physical quantity have same dimension.

Application or uses of dimension analysis.

i) To check the correctness of physical equation

ii) To establish the relationship between related physical quantites

iii) To find the conversion factor between the ~~two~~ units of the same physical quantity in two different system of units.

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Accuracy

It refer to closeness of the observed value to its true value of the quantity.

e.g. If length of a rod is 10 cm and measured by two scale

Scale 1 = 9.8 cm High Accuracy

Scale 2 = 9.1 cm low Accuracy

Precision

It refers to closeness between observed values of the measurement

e.g = 10 cm rod

Scale 1 = 8.7 cm, 8.6 cm, 8.8 cm High Precision

Scale 2 : 9.2 cm, 9.9 cm 9.5 m low Precision

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Error = It is defined as difference between actual value to measured value.

Error = True value - measured value

Types of Error.

Systematic error

If the error is either positive or negative the error is called Systematic error.

It can be ellminated by proper callibration

Systematic error arise due to improper measurement

Random errors:

The error which accures irregularly or randomly is called random error.

In random error magnitude and sign both ~~any~~ may different

Order of magnitude.

The magnitude of any physical quantity can be expressed as $A \times 10^n$ where 'A' is a number such that $0.5 \leq A < 5$ and 'n', is an integer called the order of magnitud

radius of earth = 6400km
$= 0.64 \times 10^7 m$

Singnificant figure.

Rounding off Rules

3.72 = 3.7 = because 2 < 5

3.76 = 3.8 because 6 > 5

3.752 = 3.8 (5 = 5) 8 followed by non-zero

4.653 = 4.7 (5 = 5)

3.750 = 3.8 7 is ~~even~~ odd.

3.650 = 3.6 6 is even

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Rules of Significant figures

* All non-zero digits are significant

1.224 → 4 s.f

* Trapped zero's are significant

1.004 → 4 s.f

* Initial zero are never significant.

0.001 → 1 s.f

* Ending zero are s.f. if they appear after decimal.

2.00 → 3 s.f

* order of magnitude is never significant

2.1×10^3 → 2 s.f

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Limitation of dimension analysis.

1) It can not give the value of constant

2) It can not drive relation if physical qantity depend on more than three qantity.

3. It can not drive relation if it contian more than two term

Average

Average = $\frac{\text{Sum of all data}}{\text{number of data}}$

Mean value quantity (Average quantity)

If a_1, a_2, a_3 are observed values then mean value or average value will be

$$\langle a \rangle = \frac{a_1 + a_2 + a_3}{n}$$

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Absolute error:

The magnitude of the difference between mean value and each individual value is called absolute error.

$$|\Delta a| = |\bar{a} - a_1|$$

Mean absolute error:

The arithemetic mean of all the absolute error is called mean absolute error.

$$|\Delta \bar{a}| = \frac{|\Delta a_1| + |\Delta a_2| + \dots}{n}$$

Final result of observation will be

$$a = \bar{a} \pm |\Delta \bar{a}|$$

Relative error.

The ratio of mean absolute error to its arithmetic mean value is called Relative error.

$$= \frac{|\Delta \bar{a}|}{\bar{a}}$$

Percentage error

$$\frac{|\Delta \bar{a}|}{\bar{a}} \times 100$$

Propagation of error.

Error in addition

$Y = A + B$

If ΔA is error of A

ΔB is error of B

the ΔY is error in Y

$$Y + \Delta Y = (A \pm \Delta A) \pm (B \pm \Delta B)$$

$$Y + \Delta Y = (A + B) \pm (\Delta A + \Delta B)$$

$$Y + \Delta Y = Y \pm (\Delta A + \Delta B)$$

$$\boxed{\Delta Y = (\Delta A + \Delta B)}$$

Error in subtraction

$Y = A - B$

$$Y \pm \Delta Y = (A - \Delta A) \pm (B - \Delta B)$$

$$Y \pm \Delta Y = (A - B) \pm (\Delta A - \Delta B)$$

$$\Delta Y = \pm (\Delta A - \Delta B)$$

Error in multiplication

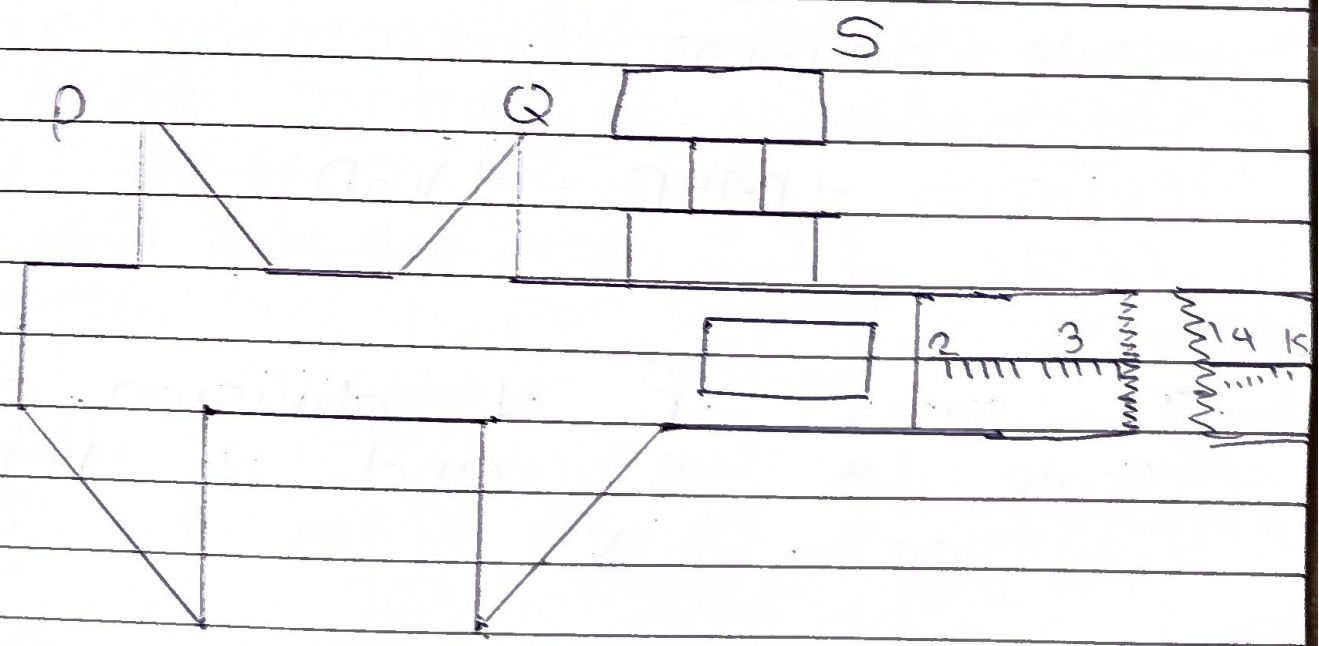
$$Y = AB$$

$$Y \times \Delta Y = (A \times \Delta A) + (B \times \Delta B)$$

$$= (A \times B) + \left(\frac{\Delta A}{A} + \Delta B\right)$$

$$\boxed{\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \frac{\Delta B}{B}}$$

Vernier callipers



It is an instrument to measure ~~up~~ to smaller length up to $\frac{1}{10}$ mm accurately

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* It consit two scale, main scale and vernier scale. fixed
* Main scale is ~~moveble~~ and vernier scale is ~~fixed~~. moveble

* The division on vernier scale are shally smaller than main scale division.

* It has two jaw, one is moveble another is fixed purpose of ~~to~~ to grip the object.

Vernier constant

It is defined as difference of value of 1 main scale division and 1 vernier scale division

$$VC = 1MSD - 1VSD$$

If value of 1 division of main scale is S and 1 vernier scale division is V

$$10V = 9S$$

If there is n division in vernier scale

$$S - V = \frac{S}{n}$$

Value of one main scale / total division of V.S

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Types of Error in vernier calliperse

a) Positive zero error

When zero marked on vernier scale lies toward right of main scale when jaw are contact the measured length will be greater than actual length

zero error = (n x l.c)

True reading = Measured value - Positive error

b) Negative zero error

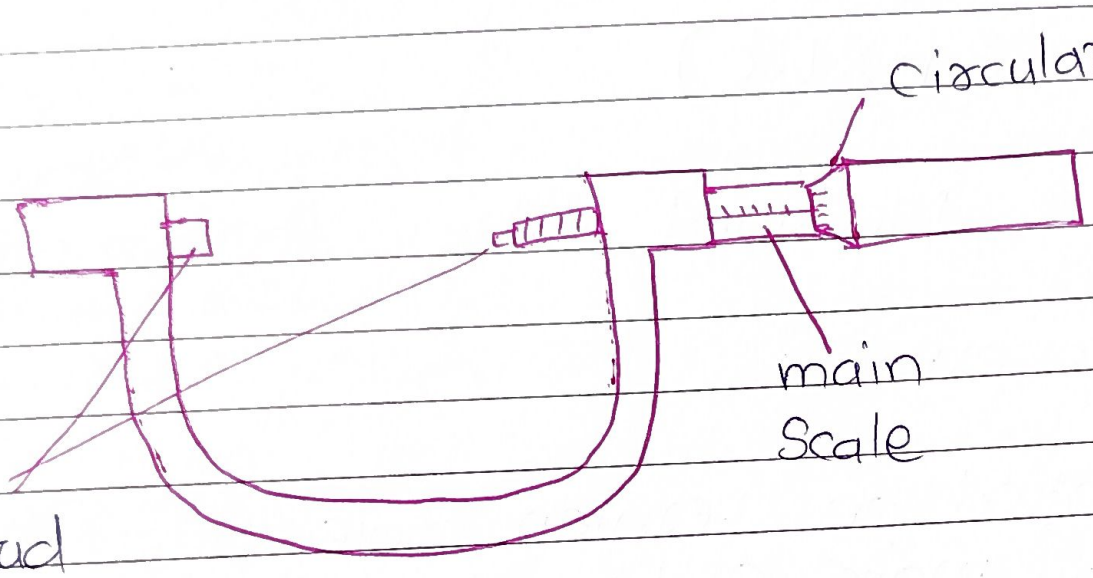
When zero marked on vernier scale lies towards left of main scale whe jaw are contact the measured length will be smaller than actual length

N.z.e = -(10-n) l.c

☆ Screw Gauge

It is an instrument which is used to measured very small length such as diameter of the thin wire, thickness of the sheet

It can measured $\frac{1}{100}$ mm length



Screw gauge cosists U-shaped metal frame

It consist main scale and circular scale

Pitch

It is defined as the linear distance moved by screw forward or backward when one complete rotation is given to circular cap

$$L.C.S.G = \frac{\text{Pitch}}{\text{Total number of division of circular scale}}$$

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zero error:

When the zero of circular scale is above or below reference line it is said that screw gauge has zero error