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Chapter No. 1

Measurements

Measurements:-
MCQs = 2 = 2
S/Qs = 4 = 8
10

PHYSICS:

The branch of science in which we deals with matter energy and their relashioship with each other.

BRANCHES OF PHYSICS:

1. **Mechanics:** The branch of physics in which we deals with the motion and its effects, of the body is called mechanics.
2. **Fluid Dynamics:** The branch of physics in which we deals with the fluids in motion.

3. Heat & Thermodynamic: The branch of physics in which we deals with the transformation of heat energy into mechanical energy.

4. Electrostatics: The branch of physics in which we deals with charges at rest.

5. Nuclear Physics: The branch of physics in which we deals with the nucleons of atoms.

6. Particle Physics: The branch of physics in which we deals with the particles of which matter is composed.

7. Solid static Physics: The branch of physics in which we deals with the properties and structures of solids are called solid static physics.

PHYSICAL Quantities

Those quantities on which foundation of physics lies

Base Quantities — Derived Quantities

1. Base quantities: Those quantities which does not define on the basis of other physical quantities

- The units of base quantities are called base units.

Quantities	Symbol	Units	Symbol
1. length	l	meter	m
2. Mass	m	Kilo[redacted] gram	kg
3. Time	t	Second	S
4. Electric Current	I	Ampere	A
5. Temperature	T	Kelvin	K
6. Amount of substance	A.O.S (n)	Mole	mol
7. Intensity of light	I.O.I (I)	Candela	Cd

Derived Quantities: Those quantities which can define on the terms of base quantities.

- The unit of these quantities are called derived units

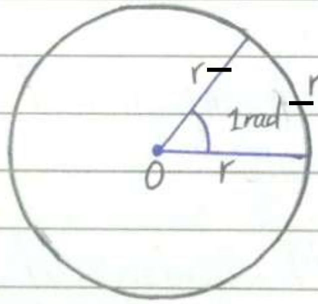
Quantities	Units (SI)	In terms of Base units
1. Force	N	$kgms^{-2}$
2. Workdone	J	kgm^2s^{-2}
3. Power	Watt	kgm^2s^{-3}

Supplymentry Quantities: (Geometrical units)

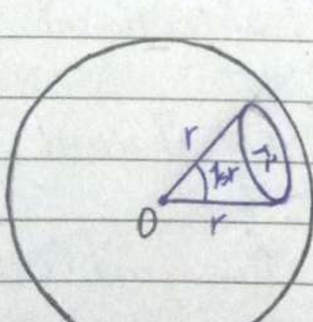
Those quantities which can not defined either on the basis of base quantities and derived quantities

Quantities	Units	Symbols
1. Plane angle	radian	rad
2. Solid angle	steradian	sr

Radian: It is the 2-Dimension angle which is made at the centre of the circle.
Whose arc length is equal to the radius of the circle.



Steradian: It is the 3-Dimension angle which is made at the centre of the sphere, by an area equal to ~~the sphere of~~ the radius of the sphere



conic shape

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Scientific Notation:

The numbers which are expressed in the multiplies of ten is called scientific notation.

$$123.7 \longrightarrow 1.23 \times 10^{2}$$

$$0.023 \longrightarrow 2.3 \times 10^{-2}$$

Conventions (Page 5 +6)
Errors and uncertainties (Page 6+7)

Significant figures:

In any measurement, the accurately known digits and the 1st doubtful digit is called significant figure.

Rules:

- All the non-zero digits are significant

$$\left.\begin{array}{l} 1234 \\ 1.234 \\ 12.34 \\ 123.4 \end{array}\right\} \rightarrow \text{4 Significant figures.}$$

- Zeros between the non-zeros digits are significant.

$$\left.\begin{array}{l} 12.04 \\ 1204 \\ 10.04 \\ 1.004 \end{array}\right\} \rightarrow \text{4 Significant figures.}$$

- Zeros on the left are not significant.

$$\left.\begin{array}{l} 0123 \\ 0.123 \\ 0.0123 \end{array}\right\} \rightarrow \text{3 Significant figures.}$$

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- Zeros on the right may or may not be significant
  (a) In decimal form

$$\left.\begin{array}{r}123.0\\12.00\\1.000\end{array}\right\} \longrightarrow \text{4 significant figures}$$

  (b) Now in an integer the significant figure depends on L.C.

- Suppose an integer 8000kg measured with an instrument having different L.C's so

Number	L.C.	Significant figures	
8000	1kg	4	$8000/1 = 8000 = 4$ S.F
8000	10kg	3	$8000/10 = 800 = 3$ S.F
8000	100kg	2	$8000/100 = 80 = 2$ S.F
8000	1000kg	1	$8000/1000 = 8 = 1$ S.F

$$\boxed{SF \propto \frac{1}{L.C}}$$

- The number written in multiplies of '10' are not significant

$2.314 \times 10^2 \rightarrow$ 4 significant figures.

Rules for rounding off:

1) 1.738 Upto two decimal
   ↳ Greater than 5 (6,7,8,9)
   1.74

2) 1.733 Upto two decimal
   ↳ less than 5 (0-4)
   1.73

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3) 1.735 $\quad$ 1.745

+1

Odd $\quad$ Even (even priority rule)

1.74 $\quad$ 1.74

Precision and Accuracy Page (10+11)

Assesment for total Uncertainity in the final Result:

To evaluate the total uncertainity or error in a calculations, it is necessary to find uncertainities.

1) For Addition End Substraction:

Absolute uncertainities are added

For example we consider two values.

$$x_1 = 10.5 \pm 0.1\,cm$$
$$x_2 = 26.8 \pm 0.1\,cm$$

In addition

$$x = x_1 + x_2$$
$$= (10.5 \pm 0.1) + (26.8 \pm 0.1)$$
$$= 37.3 \pm 0.2\,cm$$

In substraction

$$x = x_2 - x_1$$
$$= (26.8 \pm 0.1) - (10.5 \pm 0.1)$$
$$= 16.3 \pm 0.2\,cm$$

2) For Multiplication End Division:

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In case of multiplication and division, we can determine absolute uncertainties by this process for example.
we consider

$$V = 5.2 \pm 0.1\ V$$
$$I = 0.84 \pm 0.05\ A$$

Determine $R = ?$

$$R = \frac{V}{I}$$

Firstly

$$\%\text{age Uncertainity of } V = \frac{0.1}{5.2} \times 100$$
$$= 2\%$$

$$\%\text{age Unc " of } I = \frac{0.05}{0.84} \times 100$$
$$= 6\%$$

$$\text{Total }\%\text{age Unc} = 6\% + 2\%$$
$$= 8\%$$

Now calculate

$$R = \frac{V}{I}$$
$$R = \frac{5.2}{0.84}$$
$$R = 6.19\ VA^{-1}$$
$$R = 6.19\ \Omega$$

With 8% uncertainity.

Now calculate

$$\text{Uncertainity} = 6.19 \times 8\%$$
$$= \frac{6.19 \times 8}{100}$$
$$= 0.5$$

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So

$$R = 6.2 \pm 0.5\,\Omega$$

3) For Power Factor:

In power factor, to calculate the total uncertainities We consider an example.

$$V = \frac{4}{3}\pi r^3$$

$$r = 2.25 \pm 0.01\,cm$$

Firstly we calculate %age Unc

So

$$\%\text{ Unc of } r = \frac{0.01}{2.25} \times 100$$
$$= 0.4\%$$

Now

To calculate total %age Unc of r

We consider formula of

Total %age unc of r = Power x %age Unc

$$= 3 \times 0.4$$
$$= 1.2\%$$

Now calculate value

$$V = \frac{4}{3}\pi r^3$$

$$V = \frac{4}{3} \times \frac{22}{7} \times (2.25)^3$$

V = 47.689 with 1.2% Uncertainity

Now calculate Unc

$$= 47.7 \times \frac{1.2}{100}$$

$$= 0.6$$

Now

$$V = 477 \pm 0.6\ m^3$$

4) Average Values:

To calculate the uncertainities of average values, we consider six readings of micrometer.

These are

$$r_1 = 1.20 \pm 0.01$$
$$r_2 = 1.22 \pm 0.01$$
$$r_3 = 1.23 \pm 0.02$$
$$r_4 = 1.19 \pm 0.02$$
$$r_5 = 1.22 \pm 0.01$$
$$r_6 = 1.21 \pm 0.01$$

Now calculate average

$$r_{avg} = \frac{r_1 + r_2 + r_3 + r_4 + r_5 + r_6}{6}$$

$$= \frac{1.20 + 1.22 + 1.23 + 1.19 + 1.22 + 1.21}{6}$$

$$r_{avg} = 1.21\,mm$$

Now for uncertainities.

$$= \frac{0.01 + 0.01 + 0.02 + 0.02 + 0.01 + 0.01}{6}$$

$$= 0.01$$

Now

$$r_{avg} = 1.21 \pm 0.01\ mm$$

5) For timing Experiment:

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To calculate the uncertainity in timing experiment.
We consider an example.
The time period of a simple pendulum of 30 vibrations is 54.6s with stopwatch

Now

Time period for One vibration $= \frac{54.6}{30} = 1.82\,sec$

We know that least count of stopwatch $= 0.1sec$

To calculate uncertainity we consider

$$Unc = \frac{\text{Least count}}{\text{Total Vibrations}}$$

$$Unc = \frac{0.1}{30}$$

$$Unc = 0.003sec$$

Now

$$T = 1.82 \pm 0.003\ sec$$

Problem# 1.5:

Data:

$l = 10cm$

Time for 20 vibrations $= 40sec$

L.C for meter scale $= 1mm = 0.1cm$

L.C for stopwatch $= 0.1sec$

To Find:

$g = ?$

Solve:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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$$T^2 = 4\pi^2 \frac{l}{g}$$

$$g = \frac{4\pi^2 l}{T^2}$$

Time for 1 vibration $= \frac{40.2}{20} = 2.01$ sec

Now

$$g = \frac{4 \times (3.141)^2 \times 1}{(2.01)^2}$$

$$g = 9.76\ ms^{-2}$$

Now we calculate uncertainities we see

$$l = 100cm \pm 0.1cm$$

$$l = 1m \pm 0.001m$$

For time

$$\text{Unc} = \frac{L.C}{\text{Total vibration}} = \frac{0.1}{20} = 0.005$$

So

$$T = 2.01 \pm 0.005$$

Now

$$\text{\%age unc of } l = \frac{0.001}{1} \times 100$$

$$= 0.1\%$$

$$\text{\%age unc of } T = \frac{0.005}{2.01} \times 100$$

$$= 0.25\%$$

Now

$$\text{\%age unc of } T = 2 \times 0.25$$

$$= 0.5\%$$

$$\text{Total \%age unc} = 0.1\% + 0.5\%$$

$$= 0.6\%$$

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Now calculate uncertainity in g
So

$= 9.76 \times 0.6\%$
$= 0.06$

Hence
$$g = 9.76 \pm 0.06\ ms^{-2}$$

Dimensions Of Physical Quantity:

The quantative nature physical quantity is called dimensions

- It is denoted by specific symbol written in square bracket
- It is a relationship between derived physical quantity and base physical quantity
- Such as for length [L]
  for mass [M]
  for time [T]
- Some dimensions of physical quantities are:-

Speed:-
$$V = \frac{s}{t} = \frac{m}{s}$$
$$[V] = \frac{[L]}{[T]} = [LT^{-1}]$$

Acceleration:-
$$a = \frac{V}{T} = \frac{ms^{-1}}{s}$$
$$[a] = \frac{[LT^{-1}]}{[T]} = [LT^{-2}]$$

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Area:-

$A = \text{length} \times \text{breadth}$

$m \times m$

$[A] = [L][L]$

$[A] = [L^2]$

Volume:-

$V = \text{Length} \times \text{Width} \times \text{height}$

$= m \times m \times m$

$= [L][L][L]$

$V = [L^3]$

Density:-

$\rho = \frac{\text{mass}}{\text{Volume}} = \frac{kg}{m^3}$

$[\rho] = \frac{[M]}{[L^3]} = [ML^{-3}]$

Force:-

$F = ma = kgms^{-2}$

$[F] = [MLT^{-2}]$

Momentum:-

$P = mV = kgms^{-1}$

$[P] = [MLT^{-1}]$

Workdone:-

$W = Fd$

$[W] = [MLT^{-2}][L]$

$[W] = [ML^2T^{-2}]$

Torque:-

$\tau = r \times F$

$[\tau] = [L][MLT^{-2}]$

$[\tau] = [ML^2T^{-2}]$

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Energy:

$$P.E. = mgh \quad kgms^{-2}m$$
$$[P.E] = [M][LT^{-2}][L]$$
$$[P.E] = [ML^2T^{-2}]$$

Pressure:

$$P = \frac{F}{A}$$
$$[P] = \frac{[MLT^2]}{[L^2]}$$
$$[P] = [ML^{-1}T^2]$$

Kinetic energy:

$$K.E = \frac{1}{2}mv^2$$
$$[K.E] = [M][LT^{-1}]^2$$
$$[K.E] = [ML^2T^{-2}]$$

frequency:

$$v = f\lambda$$
$$f = \frac{v}{\lambda}$$
$$[f] = \frac{[LT^{-1}]}{[L]}$$
$$[f] = [T^{-1}]$$

Angular Displacement:

$$S = r\theta$$
$$\theta = \frac{S}{r}$$
$$\theta = \frac{[L]}{[L]} = [LL^{-1}]$$

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$[L^0]$ = No dimension

Also strain having no dimension.

Problem # 1.6:

Data:

Gravitational constant:

$$F = \frac{GMm}{R^2}$$

$$G = \frac{F \times R^2}{Mm}$$

$$[G] = \frac{[MLT^{-2}][L^2]}{[M][M]}$$

$$[G] = [M^{-1}L^3T^{-3}]$$

$$G = \frac{F \times R^2}{Mm} \Rightarrow \frac{N \times m^2}{(kg)^2}$$

$$G = \frac{kgms^{-2} \times m^2}{kg^2}$$

$$G = (kg^{-1}m^3s^{-2})\text{unit}$$

Eta:

$$F = 6\pi\eta rv$$

$$\eta = \text{eta}$$

$$\eta = \frac{F}{6\pi rv}$$

$$[\eta] = \frac{[MLT^{-2}]}{[L][LT^{-1}]}$$

$$[\eta] = [ML^{-1}T^{-1}]$$

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Momentum of Inertia:

$$I = mr^2$$
$$[I] = [M][L^2]$$
$$[I] = [ML^2]$$

Angular Momentum:-

$$= rp$$
$$L = mvr$$
$$[L] = [M][LT^{-1}][L]$$
$$[L] = [ML^2T^{-1}]$$

Uses Of Dimensional Analysis:

There are two uses of dimensional analysis.