UNITS AND MEASUREMENTS

SYNOPSIS

Physical Quantity:

- Any quantity which can be measured directly (or) indirectly (or) interms of which the laws of physics can be expressed is called physical quantity.
- There are two types of physical quantities
  1) Fundamental quantities 2) Derived quantities
  Fundamental Quantities: Physical quantities which cannot be expressed interms of any other physical quantities are called fundamental physical quantities.
  Ex. length, mass, time, temperature etc..
  Derived Quantities: Physical Quantities which are derived from fundamental quantities are called derived quantities.
  Ex. Area, density, force etc...

Unit of physical quantity:

- A unit of measurement of a physical quantity is the standard reference of the same physical quantity which is used for comparison of the given physical quantity.
  Fundamental unit : The unit used to measure the fundamental quantity is called fundamental unit.
  Ex: metre for length, kilogram for mass etc..
  Derived unit : The unit used to measure the derived quantity is called derived unit.
  Ex: m^2 for area, gm cm^{-3} for density etc...
- The numerical value obtained on measuring a physical quantity is inversely proportional to the magnitude of the unit chosen.

$$\boxed{n \propto \frac{1}{U}} \Rightarrow nU = \text{constant}$$

$$\Rightarrow \boxed{n_1U_1 = n_2U_2}$$

Where n_1 and n_2 are the numerical values and U_1 and U_2 are the units of same physical quantity in different systems.

System of units

- There are four systems of units
  1) F.P.S 2) C.G.S
  3) M.K.S 4) SI
- Based on SI system there are three categories of physical quantities.
  1) fundamental quantities
  2) supplementary quantities and
  3) derived quantities

Fundamental Quantities and their SI Units

- There are seven fundamental quantities and two supplementary quantities in S. I. system. These quantities along with their unit and symbols are given below:

S.No	Physical Quantity	SI unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Thermo dynamic temperature	kelvin	K (or) θ
5.	Luminous intensity	candela	Cd
6.	Electric current	ampere	A
7.	Amount of substance (or) quantity of matter	mole	mol
	Supplementary quantities		
1.	Plane angle	radian	rad
2.	Solid angle	steradian	sr

Measurement of length

- The length of an object can be measured by using different units. Some practical units of length are
  angstrom(A^o)=10^{-10} m=10^{-8} cm
  nanometre(nm) $= 10^{-9} m = 10 A^0$
  fermi $= 10^{-15} m$
  micron $= 10^{-6} m$
  X-ray unit $= 10^{-13} m$
  1 A.U. = distance between sun & earth
  $= 1.496\times10^{11}$ m
- One light year is the distance travelled by light in one year in vacuum . This unit is used in astronomy.
  Light year $= 9.46\times10^{15} m$
  parsec $= 3.26$ light years $= 30.84\times10^{15} m$
  Bohr radius $= 0.5\times10^{-10} m$
  Mile=1.6 km

Measurement of mass:

The mass of an object can be measured by using different units.Some practical units of mass are
Quintal = 100 kg
Metric ton = 1000 kg
Atomic mass unit (a.m.u) == $1.67\times10^{-27} kg$

Measurement of time:

One day = 86400 second

Shake $=10^{-8}$ second

Abbreviations for multiples and sub multiples:

MACRO Prefixes

Multiplier	Symbol	Prefix
10^{1}	da	Deca
10^{2}	h	Hecto
10^{3}	k	Kilo
10^{6}	M	Mega
10^{9}	G	Giga
10^{12}	T	Tera
10^{15}	P	Peta
10^{18}	E	Exa
10^{21}	Z	Zetta
10^{24}	Y	Yotta

MICRO Prefixes

Multiplier	Symbol	Prefix
10^{-1}	d	deci
10^{-2}	c	centi
10^{-3}	m	milli
10^{-6}	μ	micro
10^{-9}	n	nano
10^{-12}	p	pico
10^{-15}	f	femto
10^{-18}	a	atto
10^{-21}	z	zepto
10^{-24}	y	yocto

Some important conversions:

- $1kmph=\frac{5}{18}ms^{-1}$

1 newton= 10^{5} dyne

1 joule= 10^{7} erg

1 calorie=4.18 J

1eV= $1.6\times10^{-19}J$

$1gcm^{-3}=1000kgm^{-3}$

1 lit= $1000cm^{3}=10^{-3}m^{3}$

1KWH $=36\times10^{5}J$

1 HP=746 W

1 degree=0.017 rad

1cal $g^{-1}=4180JKg^{-1}$

1kgwt= 9.8 N

1 telsa= 10^{4} gauss

$1Am^{-1}=4\pi\times10^{-3}oersted$

1 weber= 10^{8} maxwell

Some physical constants and their values:

- 1 amu $=1.67\times10^{-27}kg=931.5MeV$

1 atm pressure = pressure exerted by 76cm of Hg column $=1.013\times10^{5}Pa$

Avagadro number (N)= 6.023×10^{23}

Permittivity of free space= $8.854\times10^{-12}Fm^{-1}$ or C^{2}/Nm^{2}

Permeability of free space $(\mu_0)=4\pi\times10^{-7}Hm^{-1}$

Joule's constant (J)= $4.186Jcal^{-1}$

Planck's constant(h)= $6.62\times10^{-34}Js$

Rydberg's constant(R)= $1.0974\times10^{7}m^{-1}$

Boltzmann's constant(K_B)= $1.38\times10^{-23}JK^{-1}$

Stefan's constant $(\sigma)=5.67\times10^{-8}Wm^{-2}K^{-4}$

Universal gas constant(R)= $8.314Jmol^{-1}K^{-1}$

$=1.98cal\,mol^{-1}K^{-1}$

Wien's constant(b)= $2.93\times10^{-3}metre\ kelvin$

Accuracy and precision of instruments :

- The numerical values obtained on measuring physical quantities depend upon the measuring instruments, methods of measurement.
- Accuracy refers to how closely a measured value agrees with the true value.
- Precision refers to what limit or resolution the given physical quantity can be measured.
- Precision refers to closeness between the different observed values of the same quantity .
- High precision does not mean high accuracy.
- The difference between accuracy and precision can be understood and by the following example: Suppose three students are asked to find the length of a rod whose length is known to be 2.250cm.The observations are given in the table .

Student	Measurement-1	Measurement-2	Measurement-3	Average length
A	2.25cm	2.27cm	2.26cm	2.26cm
B	2.252cm	2.250cm	2.251cm	2.251cm
C	2.250cm	2.250cm	2.250cm	2.250cm

It is clear from the above table , that the observations taken by a student A are neither precise nor accurate. The observations of student B are more precise . The observations of student C are precise as well as accurate.

Error:

- The result of every measurement by any measuring instrument contains some uncertainty. This uncertainty in measurement is called error.

Mathematically

- Error = True value - Measured value
  Correction =-error
- True value means, standard value free of errors.
- Errors are broadly classified into 3 types :
  i) Systematic errors
  ii) Random errors
  iii) Gross errors

Systematic Errors

- The errors due to a definite cause and which follow a particular rule are called systematic errors. They always occur in one direction (either +ve or -ve)
- Systematic errors with a constant magnitude are called constant errors.
  The constant arised due to imperfect design, zero error in the instrument or any other such defects. These are also called instrumental errors.
- Example for the error due to improper designing and construction.
  If a screw gauge has a zero error of -4 head scale divisions, then every reading will be 0.004cm less than the true value.
- The error arised due to external conditions like changes in environment, changes in temperature, pressure, humidity etc.
  Ex: Due to rise in temperature, a scale gets expanded and this results in error in measurement of length.

Imperfection in Experimental technique or Procedure:

- The error due to experimental arrangement, procedure followed and experimental technique is called imperfection error.
  Ex: In calorimetric experiments, the loss of heat due to radiation, the effect on weighing due to buoyancy of air cannot be avoided.

Personal errors or observational errors:

- These are entirely due to the personal peculiarities of the experimenter. Individual bias, lack of proper setting of the apparatus, carelessness in taking observations (without taking the required necessary precautions.) etc. are the causes for these type of errors. A person may be habituated to hold his eyes (head) always a bit too far to the right (or left) while taking the reading with a scale. This will give rise to parallax error.
- If a person keeps his eye-level below the level of mercury in a barometer all the time, his readings will have systematic error.

  These errors can be minimised by obtaining several readings carefully and then taking their arithmetic mean..

$$probable\ error\ \alpha \frac{1}{\text{no. of readings}}$$

Ex: Parallax error

Random Errors:

- They are due to uncontrolled disturbances which influence the physical quantity and the instrument. these errors are estimated by statistical methods.

$$\text{Random } error\ \alpha \frac{1}{\text{no. of observations}}$$

Ex-: The errors due to line voltage changes and backlash error.
Backlash errors are due to screw and nut.

Gross Errors

- The cause for gross errors are improper recording, neglecting the sources of the error, reading the instrument incorrectly, sheer carelessness
  Ex: In a tangent galvanometer experiment, the coil is to be placed exactly in the magnetic meridian and care should be taken to see that no any other magnetic material is present in the vicinity.
- No correction can be applied to these gross errors.
- When the errors are minimised, the accuracy increases.
  The systematic errors can be estimated and observations can be corrected.
- Random errors are compensating type. A physical quantity is measured number of times and these values lie on either side of mean value. These errors are estimated by statistical methods and accuracy is achieved.
- Personal errors like parallax error can be avoided by taking proper care.
- The instrumental errors are avoided by calibrating the instrument with a standard reference and by applying proper corrections.

Errors in measurement.

True Value :

- In the measurement of a physical quantity the arithmetic mean of all readings which is found to be very close to the most accurate reading is to be taken as True value of the quantities.

  If $a_1, a_2, a_3..................a_n$ are readings then true value $a_{mean} = \frac{1}{n}\sum_{i=1}^{n} a_i$

Absolute Error :

- The magnitude of the difference between the true value of the measured physical quantity and the value of individual measurement is called absolute error.
  Absolute error =|True value - measured values|

  $\Delta a_i = |a_{mean} - a_i|$

  The absolute error is always positive.

Mean absolute error:

➢ The arithmetic mean of all the absolute errors is considered as the mean absolute error of the physical quantity concerned.

$$\Delta a_{mean} = \frac{|\Delta a_1| + |\Delta a_2| + ---- + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n}|\Delta a_i|$$

The mean absolute error is always positive.

Relative error:

➢ The relative error of a measured physical quantity is the ratio of the mean absolute error to the mean value of the quantity measured.

Relative error= $\frac{\Delta a_{mean}}{a_{mean}}$

It is a pure number having no units.

Percentage error:

$$\delta a = \left[\frac{\Delta a_{mean}}{a_{mean}} \times 100\right]\%$$

Relative error and percentage error give a measure of accuracy i.e. if percentage error increases accuracy decreases.

WE- 1: ***Repetition in the measurements of a certain quantity in an experiment gave the following values: 1.29, 1.33, 1.34, 1.35, 1.32, 1.36, 1.30, and 1.33. Calculate the mean value, mean absolute error, relative error and percentage error.***

Sol. Here, mean value

$$x_m = \frac{1.29+1.33+1.34+1.35+1.32+1.36+1.30+1.33}{8}$$

= 1.3275=1.33 (rounded off to two places of decimal)

Absolute errors in measurement are

$\Delta x_1 = |1.33-1.29| = 0.04;\ \Delta x_2 = |1.33-1.33| = 0.00;$

$\Delta x_3 = |1.33-1.34| = 0.01;\ \Delta x_4 = |1.33-1.35| = 0.02;$

$\Delta x_5 = |1.33-1.32| = 0.01;\ \Delta x_6 = |1.33-1.36| = 0.03;$

$\Delta x_7 = |1.33-1.30| = 0.03;\ \Delta x_8 = |1.33-1.33| = 0.00;$

mean absolute error

$$\overline{\Delta x_m} = \frac{0.04+0.00+0.01+0.02+0.01+0.03+0.03+0.00}{8}$$

= 0.0175

= 0.02 (rounded off to two places of decimal)

Relative error $= \pm\frac{\overline{\Delta x_m}}{x_m} = \pm\frac{0.02}{1.33} = \pm 0.01503 = \pm 0.02$

(rounded off to two places of decimal)

Percentage error = $\pm 0.01503 \times 100 = \pm 1.503 = \pm 1.5\%$

WE-2 : ***The length and breadth of a rectangle are $(5.7 \pm 0.1)\,cm$ and $(3.4 \pm 0.2)\,cm$. Calculate the area of the rectangle with error limits.***

Sol. Here $l = (5.7 \pm 0.1)$ cm, $b = (3.4 \pm 0.2)$ cm

Area : $A = l \times b = 5.7 \times 3.4 = 19.38\,cm^2 = 19\,cm^2$

(rounding off to two significant figures)

$$\therefore \frac{\Delta A}{A} = \pm\left(\frac{\Delta l}{l} + \frac{\Delta b}{b}\right) = \pm\left(\frac{0.1}{5.7} + \frac{0.2}{3.4}\right)$$

$$= \pm\left(\frac{0.34+1.14}{5.7\times3.4}\right) = \pm\frac{1.48}{19.38}$$

$$\Rightarrow \Delta A = \pm\frac{1.48}{19.38} \times A = \pm\frac{1.48}{19.38} \times 19.38 = \pm 1.48 = \pm 1.5$$

(rounding off to two significant figures)

So, Area $= (19.0 \pm 1.5)\,cm^2$

WE-3: ***The distance covered by a body in time $(5.0 \pm 0.6)\,s$ is $(40.0 \pm 0.4)\,m$. Calculate the speed of the body. Also determine the percentage error in the speed.***

Sol. Here, $s = (40.0 \pm 0.4)\,m$ and $t = (5.0 \pm 0.6)\,s$

$\therefore$ Speed $v = \frac{s}{t} = \frac{40.0}{5.0} = 8.0\,ms^{-1}$ As $v = \frac{s}{t}$

$$\therefore \frac{\Delta v}{v} = \frac{\Delta s}{s} + \frac{\Delta t}{t}$$

Here $\Delta s = 0.4\,m$, s=40.0 m, $\Delta t = 0.6\,s$, t=5.0 s

$$\therefore \frac{\Delta v}{v} = \frac{0.4}{40.0} + \frac{0.6}{5.0} = 0.13$$

$$\Rightarrow \Delta v = 0.13 \times 8.0 = 1.04$$

Hence, $v = (8.0 \pm 1.04)\,ms^{-1}$

$\therefore$ Percentage error $= \left(\frac{\Delta v}{v} \times 100\right) = 0.13 \times 100 = 13\%$

WE- 4 : ***A screw gauge gives the following reading when used to measure the diameter of a wire.***
Main scale reading : 0 mm
Circular scale reading : 52 divisions
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale.
[AIEEE 2011]

Sol. Main scale reading = 0 mm

Circular scale reading = 52 divisions

$$\text{Least count} = \frac{\text{value of 1 main scale division}}{\text{Total divisions on circular scale}} = \frac{1}{100}\,mm$$

Diameter of wire = M.S.R +(C.S.R x L.C)

$$= 0 + 52 \times \frac{1}{100}\,mm = 0.52\,mm = 0.052\,cm$$

WE-5: ***The current voltage relation of diode is given by $I = \left(e^{1000V/T} - 1\right) mA$, where the applied voltage V is in volt and the temperature T is in kelvin. If a student makes an error measuring $\pm$ 0.01V while measuring the current of 5mA at 300K, what will be the error in the value of current in mA? (JEE MAIN-2014)***

Sol. $I = \left(e^{1000V/T} - 1\right) mA$

dV= $\pm$ 0.01V, T=300K, I=5mA

$I + 1 = e^{1000V/T}$

$\log\left(I+1\right) = \frac{1000V}{T}$

$\frac{dI}{I+1} = \frac{1000}{T} dV \Rightarrow$ dI=0.2mA

WE-6 : ***In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree(= 0.5^0), then the least count of the instrument is (AIEEE-2009)***

Sol. **Least count** $= \frac{\text{Value of main scale division}}{\text{No. of divisions of vernier scale}}$

$= \frac{1}{30} MSD = \frac{1}{30} \times \frac{1^0}{2} = \frac{1^0}{60} = 1$ **min**

Combination of Errors:

➢ **Error due to addition**

If $Z = A + B$;

$\Delta Z = \Delta A + \Delta B$ (Max. possible error)

$Z + \Delta Z = \left(A+B\right) \pm \left(\Delta A + \Delta B\right)$

Relative error $= \frac{\Delta A + \Delta B}{A+B}$

Percentage error $= \frac{\Delta A + \Delta B}{A+B} \times 100$

➢ **Error due to subtraction**

If Z=A-B

$\Delta Z = \Delta A + \Delta B$ (Max. possible error)

$Z + \Delta Z = \left(A-B\right) \pm \left(\Delta A + \Delta B\right)$

Relative error $= \frac{\Delta A + \Delta B}{A-B}$

Percentage error $= \frac{\Delta A + \Delta B}{A-B} \times 100$

➢ Whether it is addition or subtraction, absolute error is same.

➢ In subtraction the percentage error increases.

➢ Error due to Multiplication:

If $Z = AB$ then $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

$\frac{\Delta Z}{Z}$ is called fractional error or relative error.

Percentage error $= \frac{\Delta Z}{Z} \times 100 = \left(\frac{\Delta A}{A} \times 100\right) + \left(\frac{\Delta B}{B} \times 100\right)$

➢ Here percentage error is the sum of individual percentage errors.

➢ **Error due to division:** if $Z = \frac{A}{B}$

Maximum possible relative error $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

Max. percentage error in division

$= \frac{\Delta A}{A} \times 100 + \frac{\Delta B}{B} \times 100$

➢ **Error due to Power:** If $Z = A^n$; $\frac{\Delta Z}{Z} = n\frac{\Delta A}{A}$

➢ **In more general form :** If $Z = \frac{A^p B^q}{C^r}$

then maximum fractional error in Z is

$\frac{\Delta Z}{Z} = p\frac{\Delta A}{A} + q\frac{\Delta B}{B} + r\frac{\Delta C}{C}$

As we check for maximum error a +ve sign is to be taken for the term $r\frac{\Delta C}{C}$

Maximum Percentage error in Z is

$$\frac{\Delta Z}{Z} \times 100 = p\frac{\Delta A}{A} \times 100 + q\frac{\Delta B}{B} \times 100 + r\frac{\Delta C}{C} \times 100$$

WE-7: ***A physical quantity is represented by x =$M^a L^b T^{-c}$. The percentage of errors in the measurements of mass, length and time are $\alpha\%, \beta\%, \gamma\%$ respectively then the maximum percentage error is***

Sol. $\frac{\Delta x}{x} \times 100 = a.\frac{\Delta M}{M} \times 100 + b.\frac{\Delta L}{L} \times 100 + c.\frac{\Delta T}{T} \times 100$

$= a\alpha + b\beta + c\gamma$

WE-8: ***Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is [AIEEE 2012]***

Sol. $R = \frac{V}{I}$ $\quad [\therefore \log R = \log V - \log I]$

$$\Rightarrow \frac{\Delta R}{R}(100) = \left(\frac{\Delta V}{V} + \frac{\Delta I}{I}\right)(100)$$

$$= 3\% + 3\% = 6\%$$

WE-9: ***Two resistors of resistances*** $R_1 = (100 \pm 3)$ ***ohm and*** $R_2 = (200 \pm 4)$ ***ohm are connected (a) in series, (b) in parallel. Find the equivalent resistance of the (a) series combination, (b) parallel combination. Use for (a) the relation*** $R = R_1 + R_2$ ***and for (b)***

$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2} \quad \textit{and} \quad \frac{\Delta R'}{R'^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$$

Sol. **(a) The equivalent resistance of series combination**

$$R = R_1 + R_2 = (100 \pm 3)\,ohm + (200 \pm 4)\,ohm$$

$$= (300 \pm 7)\,ohm.$$

(b) The equivalent resistance of parallel combination

$$R' = \frac{R_1 R_2}{R_1 + R_2} = \frac{200}{3} = 66.7\,ohm$$

Then, from $\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2}$

we get, $\frac{\Delta R'}{R'^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$

$$\Delta R' = (R'^2)\frac{\Delta R_1}{R_1^2} + (R'^2)\frac{\Delta R_2}{R_2^2}$$

$$= \left(\frac{66.7}{100}\right)^2 3 + \left(\frac{66.7}{200}\right)^2 4 \; = 1.8$$

Then, $R' = (66.7 \pm 1.8)\,ohm$

Significant Figures :

- A significant figure is defined as the figure, which is considered reasonably, trust worthy in number.

Ex: π = 3.141592654 (upto 10 digits)
=3.14 (with 3 figures)
=3.1416 (upto 5 digits)

- The significant figures indicate the extent to which the readings are reliable.

Rules for determining the number of significant figures:

- All the non-zero digits in a given number are significant without any regard to the location of the decimal point if any.
  Ex: 18452 or 1845.2 or 184.52 all have the same number of significant digits,i.e. 5.
- All zeros occurring between two non zero digits are significant without any regard to the location of decimal point if any.
  Ex: 106008 has six significant digits.
  106.008 or 1.06008 has also got six significant digits.
- If the number is less than one, all the zeros to the right of the decimal point but to the left of first non-zero digit are not significant.
  Ex: 0.000308
  In this example all zeros before 3 are insignificant.
- a)All zeros to the right of a decimal point are significant if they are not followed by a non-zero digit.
  Ex: 30.00 has 4 significant digits
- b) All zeros to the right of the last non-zero digit after the decimal point are significant.
  Ex: 0.05600 has 4 significant digits
- c) All zeros to the right of the last non-zero digit in a number having no decimal point are not significant.
  Ex: 2030 has 3 significant digits

Rounding off numbers:

- The result of computation with approximate numbers, which contain more than one uncertain digit,should be rounded off.

Rules for rounding off numbers:

- The preceding digit is raised by 1 if the immediate insignificant digit to be dropped is more than 5.
  Ex: 4728 is rounded off to three significant figures as 4730.
- The preceding digit is to be left unchanged if the immediate insignificant digit to be dropped is less than 5.
  Ex: 4723 is rounded off to three significant figures as 4720
- If the immediate insignificant digit to be dropped is 5 then there will be two different cases
  a) If the preceding digit is even then it is to be unchanged and 5 is dropped.
  Ex: 4.7253 is to be rounded off to two decimal places. The digit to be dropped here is 5 (along with 3) and the preceding digit 2 is even and hence to be retained as two only 4.7253=4.72

b)If the preceding digit is odd, it is to be raised by 1
Ex: 4.7153 is to be rounded off to two decimal places. As the preceding digit '1' is odd, it is to be raised by 1.
4.7153=4.72

Rules for Arithmetic Operations with significant Figures:

- In multiplication or division, the final result should retain only that many significant figures as are there in the original number with the least number of significant figures.
  Ex: $1.2\times2.54\times3.26=9.93648$. But the result should be limited to the least number of significant digits-that is two digits only. So final answer is 9.9.
- In addition or subtraction the final result should retain only that many decimal places as are there in the number with the least decimal places.
  Ex: 2.2+4.08+3.12+6.38=15.78. Finally we should have only one decimal place and hence 15.78 is to be rounded off as 15.8.

WE-10:** The respective number of significant figures for the numbers 23.023, 0.0003 and 21×10^{-3} are* ***(AIEEE-2010)

Sol. (i) All non-zero numbers are significant figures. Zeros occurring between zero digits are also significant.
(ii) If the number is less than one, zero between the decimal and first non zero digit are not significant.
(iii) Powers of 10 is not a significant figure.
$\therefore$ 5,1,2

Dimensions of physical quantities:

- Dimensions of a physical quantity are the powers to which the fundamental quantities are to be raised to represent that quantity.

Dimensional Formula :

- An expression showing the powers to which the fundamental quantities are to be raised to represent the derived quantity is called dimensional formula of that quantity.
  In general the dimensional formula of a quantity can be written as $\left[M^xL^yT^z\right]$. Here x,y,z are dimensions.

Dimensional Constants:

- The physical quantities which have dimensions and have a fixed value are called dimensional constants.
  Ex: Gravitational constant (G), Planck's constant (h), Universal gas constant (R), Velocity of light in vacuum (c) etc.,

Dimensionless Quantities:

- Dimensionless quantities are those which do not have dimensions but have a fixed value.
  (a): Dimensionless quantities without units.
  Ex: Pure numbers, angle trigonometric functions, logarthemic functions etc.,
  (b) Dimensionless quantities with units.
  Ex: Angular displacement - radian, Joule's constant etc.,

Dimensional variables:

- Dimensional variables are those physical quantities which have dimensions and do not have fixed value.
  Ex: velocity, acceleration, force, work, power.etc.

Dimensionless variables:

- Dimensionless variables are those physical quantities which do not have dimensions and do not have fixed value.,
  Ex: Specific gravity, refractive index, Coefficient of friction, Poisson's Ratio etc.,

Limitations of dimensional analysis method:

- Dimensionless quantities cannot be determined by this method. Constant of proportionality cannot be determined by this method. They can be found either by experiment (or) by theory.
- This method is not applicable to trigonometric, logarithmic and exponential functions.
- In the case of physical quantities which are dependent upon more than three physical quantities, this method will be difficult.
- In some cases, the constant of proportionality also possesses dimensions. In such cases we cannot use this system.
- If one side of equation contains addition or subtraction of physical quantities, we cannot use this method.

The following is the list of some physical quantities with their formulae and dimensional formulae with units

S.No. Physical Quantity	Explanation or Formulae	Dimensional Formulae	S.I.Unit
1. Distance, Displacement, Wave length, Radius of gyration, Circumference, Perimeter, Light year,		$\left[M^0\ L^1\ T^0\right]$	m
2. Mass		$\left[M^1\ L^0\ T^0\right]$	kg
3. Period of oscillation, Time, Time constant	$\frac{\text{total time}}{\text{no.of oscillations}}$ T = Capacity $\times$ Resistance	$\left[M^0\ L^0\ T^1\right]$	s
4. Frequency	Reciprocal of time period $n=\frac{1}{T}$	$\left[M^0L^0T^{-1}\right]$	hertz (Hz)
5. Area	A = length $\times$ breadth	$\left[M^0L^2T^0\right]$	m^2
6. Volume	V=length$\times$breadth$\times$height	$\left[M^0L^3T^0\right]$	m^3
7. Density	$d=\frac{\text{mass}}{\text{volume}}$	$\left[M^1L^{-3}T^0\right]$	kgm^{-3}
8. Linear mass density	$\lambda=\frac{\text{mass}}{\text{length}}$	$\left[M^1L^{-1}T^0\right]$	kgm^{-1}
9. Speed, Velocity	$v=\frac{\text{displacement}}{\text{time}}$	$\left[M^0L^1T^{-1}\right]$	ms^{-1}
10. Acceleration	$a=\frac{\text{change in velocity}}{\text{time}}$	$\left[M^0L^1T^{-2}\right]$	ms^{-2}
11. Linear momentum	P= mass $\times$ velocity	$\left[M^1L^1T^{-1}\right]$	$kgms^{-1}$
12. Force	F = Mass $\times$ acceleration	$\left[M^1L^1T^{-2}\right]$	N
13. Impulse	J= Force $\times$ time	$\left[M^1L^1T^{-1}\right]$	Ns
14. Work, Energy, PE, KE, Strain energy, Heat energy	W = Force$\times$displacement P.E= mgh KE = $\frac{1}{2}$ (Mass) (velocity)^2 SE= $\frac{1}{2}\times$Stress$\times$Strain$\times$volume	$\left[M^1L^2T^{-2}\right]$	J(or) N.m
15. Power	$P=\frac{\text{Work}}{\text{time}}$	$\left[M^1L^2T^{-3}\right]$	watt
16. Pressure, Stress, Modulus of elasticity (Y, η, k)	$\frac{\text{Force}}{\text{Area}}$ $Y=\frac{\text{Stress}}{\text{Strain}}$	$\left[M^1L^{-1}T^{-2}\right]$	pascal or Nm^{-2}

17.	Strain	$=\frac{\text{change in dimension}}{\text{original dimension}}$	$\left[M^0L^0T^0\right]$	no units
18.	Strain energy density	$E=\frac{\text{work}}{\text{volume}}$	$\left[M^1L^{-1}T^{-2}\right]$	Jm^{-3}
19.	Angular displacement	$\theta=\frac{\text{length of arc}}{\text{radius}}$	$\left[M^0L^0T^0\right]$	rad
20.	Angular velocity	$\omega=\frac{\text{angular dispacement}}{\text{time}}$	$\left[M^0L^0T^{-1}\right]$	$rads^{-1}$
21.	Angular acceleration	$\alpha=\frac{\text{change in angular velocity}}{\text{time}}$	$\left[M^0L^0T^{-2}\right]$	$rads^{-2}$
22.	Angular momentum	L=linear momentum $\times$ perpendicular distance	$\left[M^1L^2T^{-1}\right]$	Js
23.	Planck's constant	$h=\frac{\text{energy}}{\text{frequency}}$	$\left[M^1L^2T^{-1}\right]$	Js
24.	Angular impulse	Torque $\times$ time	$\left[M^1L^2T^{-1}\right]$	Js
25.	Torque	τ=force$\times\perp$ distance	$\left[M^1L^2T^{-2}\right]$	Nm
26.	Acceleration due to gravity(g)	$g=\frac{\text{weight}}{\text{mass}}$	$\left[M^0LT^{-2}\right]$	ms^{-2} or Nkg^{-1}
27.	Universal gravitational Constant	$G=\frac{\text{Force}\times(\text{distance})^2}{\text{Mass}_1\times\text{Mass}_2}$	$\left[M^{-1}L^3T^{-2}\right]$	$Nm^2\ kg^{-2}$
28.	Moment of inertia	I=Mass $\times$ (radius of gyration)^2	$\left[M^1L^2T^0\right]$	kgm^2
29.	Velocity gradient	$=\frac{dv}{dx}$	$\left[M^0L^0T^{-1}\right]$	S^{-1}
30.	Surface tension, Surface energy	$S=\frac{\text{surface energy}}{\text{change in area}}=\frac{\text{force}}{\text{length}}$	$\left[M^1L^0T^{-2}\right]$	Nm^{-1} or Jm^{-2}
	Spring constant Force constant	$K=\frac{\text{force}}{\text{elongation}}$		
31.	Coefficient of viscosity	$\eta=\frac{\text{tangential stress}}{\text{velocity gradient}}$	$\left[M^1L^{-1}T^{-1}\right]$	Pa s (or) $Nm^{-2}s$
32.	Gravitational potential	Gravitational field $\times$ distance	$\left[M^0L^2T^{-2}\right]$	J/Kg
33.	Heat energy	$ms\theta$	$\left[M^1L^2T^{-2}\right]$	joule
34.	Temperature	θ	$\left[M^0L^0T^0\theta^1\right]$	kelvin(K)
35.	Specific heat capacity	S (or) $C=\frac{\text{heat energy}}{\text{mass}\times\text{temp.}}$	$\left[M^0L^2T^{-2}\theta^{-1}\right]$	$Jkg^{-1}\ K^{-1}$
36.	Thermal capacity	$\frac{dQ}{d\theta}$=mass$\times$specific heat	$\left[M^1L^2T^{-2}\theta^{-1}\right]$	JK^{-1}

37.	Latent heat (or) Calorific value	$L=\frac{\text{heat energy}}{\text{mass}}$	$\left[M^0L^2T^{-2}\right]$	Jkg^{-1}
38.	Water equivalent	W=Mass $\times$ specific heat	$\left[M^1L^0T^0\right]$	kg
39.	Coefficient of thermal expansion	$\alpha=\frac{\Delta l}{l\Delta\theta};\beta=\frac{\Delta A}{A\Delta\theta};\gamma=\frac{\Delta V}{V\Delta\theta}$	$\left[M^0L^0T^0\theta^{-1}\right]$	K^{-1}
40.	Universal gas constant	$R=\frac{PV}{nT}$	$\left[M^1L^2T^{-2}\theta^{-1}mol^{-1}\right]$	$Jmol^{-1}K^{-1}$
41.	Gas constant (for 1 gm)	$r=\frac{R}{\text{Mol.wt}}$	$\left[M^0L^2T^{-2}\theta^{-1}mol^{-1}\right]$	$Jkg^{-1}K^{-1}$
42.	Boltzmann's constant (for 1 Molecule)	$k=\frac{R}{\text{Avagadro number}}$	$\left[M^1L^2T^{-2}\theta^{-1}\right]$	$JK^{-1}molecule^{-1}$
43.	Mechanical equivalent of heat	$J=\frac{W}{H}$	$\left[M^0L^0T^0\right]$	no SI units
44.	Coefficient of thermal conductivity	$K=\frac{Qd}{A\ \Delta\theta t}$	$\left[M^1L^1T^{-3}\theta^{-1}\right]$	$Js^{-1}\ m^{-1}\ K^{-1}$ (or) $Wm^{-1}\ K^{-1}$
45.	Entropy	$\frac{dQ}{T}=\frac{\text{heat energy}}{\text{temperature}}$	$\left[M^1L^2T^{-2}\theta^{-1}\right]$	JK^{-1}
46.	Stefan's constant	$\sigma=\frac{\Delta E}{\Delta A\Delta T\theta^4}$	$\left[M^1L^0T^{-3}\theta^{-4}\right]$	$Js^{-1}m^{-2}K^{-4}$ (or) $Wm^{-2}K^{-4}$
47.	Thermal resistance	$R=\frac{d\theta}{\left(\frac{dQ}{dt}\right)}=\frac{\text{temp}\times\text{time}}{\text{Heat}}$ (or) $R=\frac{d}{KA}$	$\left[M^{-1}L^{-2}T^3\theta^1\right]$	KsJ^{-1}
48.	Temperature gradient	$\frac{\text{Change in temp}}{\text{length}}=\frac{d\theta}{dl}$	$\left[M^0L^{-1}T^0\theta^1\right]$	Km^{-1}
49.	Pressure gradient	$\frac{\text{Change in pressure}}{\text{length}}=\frac{dp}{dl}$	$\left[M^1L^{-2}T^{-2}\right]$	pascal m^{-1}
50.	Solar constant	$\frac{\text{Energy}}{\text{area}\times\text{time}}=\frac{\Delta E}{AT}$	$\left[M^1L^0T^{-3}\right]$	$Js^{-1}m^{-2}$ (or) Wm^{-2}
51.	Enthalpy	heat (ΔQ)	$\left[M^1L^2T^{-2}\right]$	joule
52.	Pole strength	m=IL (or) $\frac{\text{Magnetic Momement}}{\text{Mag.Length}}$	$\left[M^0LT^0A\right]$	Am
53.	Magnetic moment	$M=2l\times m$	$\left[M^0L^2T^0A\right]$	Am^2

54.	Magnetic intensity (or) Magnetising field	$H=\frac{m}{4\pi d^2}$	$\left[M^0L^{-1}T^0A\right]$	Am^{-1}
55.	Intensity of magnetisation	$I=\frac{\text{Magnetic moment}}{\text{Volume}}$	$\left[M^0L^{-1}T^0A\right]$	Am^{-1}
56.	Magnetic flux	$\varphi = \vec{B}\times\vec{A}$ =(Magnetic induction $\times$ Area)	$\left[M^1L^2T^{-2}A^{-1}\right]$	Wb
57.	Magnetic induction	$\vec{B}=\frac{\phi}{A}=\frac{\text{Magnetic flux}}{\text{Area}}=\frac{F}{il}$	$\left[M^1L^0T^{-2}A^{-1}\right]$	Tesla (or) Wbm^{-2} (or) $NA^{-1}m^{-1}$
58.	Magnetic permeability	$=\frac{4\pi Fd^2}{m_1m_2}$	$\left[M^1L^1T^{-2}A^{-2}\right]$	Hm^{-1}
59.	Magnetic susceptibility	$\chi=\frac{I}{H}$	$\left[M^0L^0T^0\right]$	no units
60.	Electric current	I	$\left[M^0L^0T^0A\right]$	A
61.	Charge	Q =Current $\times$ Time	$\left[M^0L^0TA\right]$	C
62.	Electric dipole moment	P=Charge $\times$ Distance	$\left[M^0L^1AT\right]$	Cm
63.	Electric field strength (or) Electric field intensity	$E=\frac{\text{Force}}{\text{Charge}}$	$\left[M^1LT^{-3}A^{-1}\right]$	NC^{-1}
64.	Electrical flux (ϕ_E)	Electrical intensity $\times$ area	$\left[M^1L^3T^{-3}A^{-1}\right]$	$Nm^2\ C^{-1}$
65.	Electric potential (or) Potential difference	$V=\frac{\text{Work}}{\text{Charge}}$	$\left[M^1L^2T^{-3}A^{-1}\right]$	V
66.	Electrical resistance	$R=\frac{\text{Pot.diff}}{\text{Current}}$	$\left[M^1L^2T^{-3}A^{-2}\right]$	Ω
67.	Electrical conductance	$C=\frac{1}{R}=\frac{1}{\text{Resistance}}$	$\left[M^{-1}L^{-2}T^3A^2\right]$	mho (or) Siemen (S)
68.	Specific resistance (or Resistivity ρ (or) s	$\rho=\frac{RA}{l}$	$\left[M^1L^3T^{-3}A^{-2}\right]$	Ohm-m
69.	Electrical conductivity	$\sigma=\frac{1}{\text{Resistivity}}$	$\left[M^{-1}L^{-3}T^3A^2\right]$	$Ohm^{-1}\ m^{-1}$ (or) Siemen m^{-1}
70.	Current density (current per unit area of cross section)	J = Electrical intensity $\times$ Conductivity or $\left(\frac{\text{Current}}{\text{Area}}\right)$	$\left[M^0L^{-2}T^0A\right]$	Am^{-2}
71.	Capacitance	$C=\frac{Q}{V}=\frac{\text{Charge}}{\text{Potential}}$	$\left[M^{-1}L^{-2}T^4A^2\right]$	F
72.	Self (or) Mutual inductance	$L=\frac{d\varepsilon}{\left(\frac{dI}{dt}\right)}=\frac{\text{Voltage}\times\text{Time}}{\text{Current}}$	$\left[M^1L^2T^{-2}A^{-2}\right]$	H(or) Wb/amp

73.	Electrical permittivity	$\varepsilon=\frac{q_1q_2}{4\pi Fd^2}$	$\left[M^{-1}L^{-3}T^4A^2\right]$	farad/m
74.	Surface charge density	$\frac{\text{Charge}}{\text{Area}}$	$\left[M^0L^{-2}T^1A^1\right]$	Cm^{-2}
75.	Luminous flux	$\frac{\text{Light energy}}{\text{Time}}$	$\left[M^1L^2T^{-3}\right]$	lumen
76.	Intensity of illumination (or) Iluminance	$I=\frac{\Delta E}{\Delta t\Delta A}=\left(\frac{\text{Luminous flux}}{\text{Area}}\right)$	$\left[M^1L^0T^{-3}\right]$	lumen m^2 (or) lux.
77.	Focal power	$P=\frac{1}{\text{Focal length}}$	$\left[M^0L^{-1}T^0\right]$	dioptre
78.	Wave number (Propagation constant)	$\bar{v}=\frac{1}{\lambda}$	$\left[M^0L^{-1}T^0\right]$	m^{-1}
79.	Rydberg's constant	$R=\frac{Z^2e^4m}{8\varepsilon_0^2ch^3}$	$\left[M^0L^{-1}T^0\right]$	m^{-1}

WE-11: ***Let $[\varepsilon_0]$ denote the dimensional formula of permittivity of vacuum .If M is mass ,L is length,T is time and A is electric current,then (JEE-MAIN 2013)***

Sol: **From coulomb's law** $F=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{R^2}$

$$\varepsilon_0=\frac{q_1q_2}{4\pi FR^2}$$

Substituting the units

$$\varepsilon_0=\frac{c^2}{N-m^2}=\frac{[AT]^2}{\left[MLT^{-2}\right]\left[L^2\right]}$$

$$=\left[M^{-1}L^{-3}T^4A^2\right]$$

WE-12: ***The dimensional formula of magnetic field strength in M, L, T and C (coulomb) is given as (AIEEE 2008)***

Sol: From F = Bqv

$$B=\frac{F}{qv}=\frac{\left[MLT^{-2}\right]}{C\left[LT^{-1}\right]}=\left[M^1L^0T^{-1}C^{-1}\right]$$

Physical Quantities Having Same Dimensional Formulae:

- Distance, Displacement, radius,wavelength, radius of gyration [L]
- Speed, Velocity, Velocity of light $\left[LT^{-1}\right]$
- acceleration ,acceleration due to gravity, intensity of gravitational field, centripetal acceleration $\left[LT^{-2}\right]$
- Impulse, Change in momentum $\left[MLT^{-1}\right]$-size changed
- Force, Weight, Tension,energy gradient, Thrust $\left[MLT^{-2}\right]$ -- size changed
- Work, Energy, Moment of force or Torque, Moment of couple $\left[ML^2T^{-2}\right]$ -- size changed
- Force constant, Surface Tension, Spring constant, surface energy i.e. Energy per unit area $\left[MT^{-2}\right]$- size changed
- Angular momentum, Angular impulse, Planck's constant $\left[ML^2T^{-1}\right]$ - size changed
- Angular velocity, Frequency, angular frequency,Velocity gradient,
- Decay constant, rate of disintegration $[T^{-1}]$
- Stress, Pressure, Modulus of Elasticity, Energy density $\left[ML^{-1}T^{-2}\right]$
- Latent heat, Gravitational potential $\left[L^2T^{-2}\right]$

- Specific heat, Specific gas constant $\left[L^2T^{-2}\theta^{-1}\right]$
- Thermal capacity, Entropy, Boltzmann constant, Molar thermal capacity, $\left[ML^2T^{-2}\theta^{-1}\right]$
- Wave number, Power of a lens, Rydberg's constant $\left[L^{-1}\right]$
- Time, RC, $\frac{L}{R}$, $\sqrt{LC}$,$[T^{-1}]$
- Power, Rate of dissipation of energy, $\left[ML^2T^{-3}\right]$
- Intensity of sound, Intensity of radiation $[MT^{-3}]$
- Electric potential, potential difference, electromotive force $[ML^2T^{-3}I^{-1}]$
- Intensity of magnetic field, Intensity of magnetization $\left[IL^{-1}\right]$
- Electric field and potential gradient $\left[MLT^{-3}A^{-1}\right]$
- Rydberg's constant and propagation constant $\left[M^0L^{-1}T^0\right]$
- Strain , Poisson's ratio, refractive index, dielectric constant, coefficient of friction, relative permeability, magnetic susceptibility, electric susceptibility, angle, solid angle, trigonometric ratios,logarithm function, exponential constant are all dimensionless.
- If L,C and R stands for inductance, capacitance and resistance respectively then $\frac{L}{R}, \sqrt{LC}, RC$ and time $\left[M^0L^0T\right]$
- Coefficient of linear expansion, coefficient of superficial expansion and coefficient of cubical expansion,temperature coefficient of resistance $\left[M^0L^0T^0K^{-1}\right]$
- Solar constant and poynting vector$\left[ML^0T^{-3}\right]$

Principle of homogeneity:

- It states that only quantities of same dimensions can be added, subtracted and equated.

WE-13: ***The dimensional formula of $\frac{a}{b}$ in the equation $P = \frac{a-ct^2}{bx}$ where P = pressure, x = displacement and t = time***

Sol : $[P] = \left[\frac{a}{bx}\right] - \left[\frac{ct^2}{bx}\right]$

By principle of Homogeneity,

$\left[\frac{a}{bx}\right]$ should represent pressure

$\therefore \left[\frac{a}{b}\right]\frac{1}{L} = \left[ML^{-1}T^{-2}\right] \Rightarrow \left[\frac{a}{b}\right] = \left[MT^{-2}\right]$

Uses of dimensional analysis method:

- **To check the correctness of the given equation.** (This is based on the principle of homogeneity)
- **To convert one system of units into another system.**
- **To derive the equations showing the relation between different physical quantities.**

WE-14: ***Check whether the relation $S = ut + \frac{1}{2}at^2$ is dimensionally correct or not, where symbols have their usual meaning.***

Sol: We have $S = ut + \frac{1}{2}at^2$. checking the dimensions on both sides, LHS=$[S] = \left[M^0L^1T^0\right]$,

RHS=$[ut] + \left[\frac{1}{2}at^2\right] = \left[LT^{-1}\right][T] + \left[LT^{-2}\right]\left[T^2\right]$

$= \left[M^0L^1T^0\right] + \left[M^0L^1T^0\right] = \left[M^0L^1T^0\right]$

we find LHS=RHS.

Hence, the formula is dimensionally correct.

WE-15: ***Young's modulus of steel is $19\times10^{10}\,N/m^2$. Express it in $dyne/cm^2$. Here dyne is the CGS unit of force.***

Sol: The SI unit of Young's modulus is N/m^2.

Given $Y = 19\times10^{10}\,\frac{N}{m^2} = 19\times10^{10}\left(\frac{10^5\,dyne}{\left(10^2\,cm\right)^2}\right)$

$= 19\times10^{11}\left(\frac{dyne}{cm^2}\right)$

WE-16 : ***For a particle to move in a circular orbit uniformly, centripetal force is required, which depends upon the mass (m), velocity (v) of the particle and the radius (r) of the circle. Express centripetal force in terms of these quantities***

Sol: According to the provided information,

let $F \propto m^a v^b r^c$. $\Rightarrow F = km^a v^b r^c$

$\Rightarrow \left[M^1L^1T^{-2}\right] = \left[M^a\left(LT^{-1}\right)^b L^c\right]$

$\Rightarrow\left[M^1L^1T^{-2}\right]=\left[M^aL^{b+c}T^{-b}\right]$

using principle of homogeneity we have

a = 1 ,b + c = 1 ,b = 2

on solving we have a = 1, b = 2, c = -1

using these values we get F = $km^1v^2r^{-1}$

$\Rightarrow F=k\dfrac{mv^2}{r}$

Note: The value of the dimensionless constant k is to be found experimentally.

***WE-17:* Derive an expression for the time period of a simple pendulum of mass(m), length (l) at a place where acceleration due to gravity is (g).**

Sol: Let the time period of a simple pendulum depend upon the mass of bob m, length of pendulum l, and acceleration due to gravity g, then

$t\propto m^al^bg^c\Rightarrow t=km^al^bg^c$

$M^0L^0T^1=M^aL^b\left[LT^{-2}\right]^c$

$\Rightarrow M^0L^0T^1=M^aL^{b+c}T^{-2c}$

comparing the powers of M, L, and T on both sides, we get a = 0, b + c = 0, -2c=1

$\Rightarrow$ a = 0, b = 1/2 and c = -1/2. Putting these values,

we get $T=km^0\dfrac{l^{1/2}}{g^{1/2}}\Rightarrow T=k\sqrt{\dfrac{l}{g}}$,

which is the required relation.

***WE18:* If C is the velocity of light, h is Planck's constant and G is Gravitational constant are taken as fundamental quantities, then the dimensional formula of mass is.(Eamcet - 2014)**

Sol: $C=\left[LT^{-1}\right]\to(1)$; $h=\left[ML^2T^{-1}\right]\to(2)$

$G=\left[M^{-1}L^3T^{-2}\right]\to(3)$

Solving (2) and (3)

$\dfrac{h}{G}=\left[\dfrac{ML^2T^{-1}}{M^{-1}L^3T^{-2}}\right]=\left[M^2L^{-1}T^1\right]$

Substituting (1) in above

$\dfrac{h}{G}=\dfrac{M^2}{C}\Rightarrow[\mathrm{M}]=\left[\mathrm{h}^{\frac{1}{2}}\mathrm{G}^{\frac{-1}{2}}\mathrm{C}^{\frac{1}{2}}\right]$

***WE19:* If E, M, J and G respectively denote energy, mass, angular momentum and universal gravitational constant, the quantity, which has the same dimensions as the dimensions of $\dfrac{EJ^2}{M^5G^2}$ (Eamcet - 2013)**

Sol : D.F. of $\dfrac{EJ^2}{M^5G^2}$

Substituting D.F. of E, J, M, and G in above formula

$=\dfrac{ML^2T^{-2}\left[ML^2T^{-1}\right]^2}{M^5\left[M^{-1}L^3T^{-2}\right]^2}=\left[M^0L^0T^0\right]$

***WE20:* In the equation $\left(\dfrac{1}{p\beta}\right)=\dfrac{y}{k_BT}$ where p is the pressure, y is the distance, k_B is Boltzmann constant and T is the temperature. Dimensions of β are (Med- 2013)**

Sol. $\dfrac{1}{p\beta}=\dfrac{y}{k_BT}$

Dimension of

$[\beta]=\dfrac{[\text{Dimensional formula of } k_B][\text{Dimensional formula of } T]}{[\text{Dimensional formula of } p][\text{Dimensional formula of } y]}$

$=\dfrac{\left[ML^2T^{-3}\right][T]}{\left[ML^{-1}T^{-2}\right][L]}=\left[M^0L^2T^0\right]$

$\therefore$ Dimensions of M,L,T in β are 0,2,0

***WE21:* The vander Waal's equation for n moles of a real gas is $\left(p+\dfrac{a}{V^2}\right)(V-b)=nRT$ where p is pressure, V is volume, T is absolute temperature, R is molar gas constant a, b and c are vander Waal's constants. The dimensional formula for ab is (Med- 2012)**

Sol. By principle of homogenity of dimensions P can added to P only. It means $\dfrac{a}{V^2}$ also gives pressure.

Dimension formulae for pressure $(P)=\left[M^1L^{-1}T^{-2}\right]$

and Volume $(V)=\left[M^0L^3T^0\right]$

Since $\dfrac{a}{V^2}$ = pressure

$\therefore\dfrac{a}{\left(M^0L^3T^0\right)}=\left[M^1L^{-1}T^{-2}\right]\Rightarrow\dfrac{a}{M^0L^6T^0}=\left[M^1L^{-1}T^{-2}\right]$

$\therefore a=\left[M^1L^5T^{-2}\right]$

similarly, b will have same dimensions as volume $V-b=volume$

$\therefore b=\left[M^0L^3T^0\right]$

$\therefore[ab]=\left[M^1L^5T^{-2}\right]\left[M^0L^3T^0\right]=\left[M^1L^8T^{-2}\right]$

W.E-22: ***A screw gauge having 100 equal divisions and a pitch of length 1 mm is used to measure the diameter of a wire of length 5.6 cm. The main scale reading is 1 mm and 47th circular division coincides with the main scale. Find the curved surface area of the wire in cm^2 to appropriate significant figures.(Use π = 22/7)***

Sol. Least Count $= \frac{1mm}{100} = 0.01mm$

Diameter = MSR + CSR(LC) = 1 mm+47 (0.01) mm = 1.47 mm

Surface area $= \pi Dl = \frac{22}{7} \times 1.47 \times 56 mm^2$

$= 2.58724\,cm^2 = 26cm^2$

W.E-23: ***In Searle's experiment, the diameter of the wire as measured by a screw gauge of least count 0.001 cm is 0.050 cm. The length, measured by a scale of least count 0.1 cm, is 110.0 cm. When a weight of 50 N is suspended from the wire, the extension is measured to be 0.125 cm by a micrometer of least count 0.001 cm. Find the maximum error in the measurement of Young's modulus of the material of the wire from these data.***

Sol. Maximum percentage error in Y is given by

$$Y = \frac{W}{\frac{\pi D^2}{4}} \times \frac{L}{x} \Rightarrow \left(\frac{\Delta Y}{Y}\right) = 2\left(\frac{\Delta D}{D}\right) + \frac{\Delta x}{x} + \frac{\Delta L}{L}$$

$$= 2\left(\frac{0.001}{0.05}\right) + \left(\frac{0.001}{0.125}\right) + \left(\frac{0.1}{110}\right) = 0.0489$$

W.E24: ***The side of a cube is measured by vernier calipers (10 divisions of the vernier scale coincide with 9 divisions of the main scale, where 1 division of main scale is 1 mm). The main scale reads 10 mm and first division of vernier scale coincides with the main scale. Mass of the cube is 2.736 g. Find the density of the cube in appropriate significant figures.***

Sol. Least count of vernier calipers

$$= \frac{1\,division\ of\ main\ scale}{Number\ of\ divisions\ in\ vernier\ scale} = \frac{1}{10} = 0.1\,mm$$

The side of cube = 10 mm + $1 \times 0.1\,mm = 1.01\,cm$

Now, density $= \frac{Mass}{Volume} = \frac{2.736g}{(1.01)^3\,cm^3} = 2.66\,g\,cm^{-3}$

C.U.Q

UNITS & MEASUREMENTS

1. The reliability of a measurement depends on
1) precision 2) accuracy
3) systematic error 4) random error

2. The error due to resolution of a measuring instrument is
1) personal error 2) random error
3) systematic error 4) gross error

3. The error due to resolution of a measuring instrument is
1) random error 2) personal error
3) gross error 4) least count error

4. The random error which exists invariably in screw gauge is
1) least count error 2) Zero error
3) gross error 4) backlash error

5. The errors which are estimated by statistical methods are
1) systematic errors 2) random errors
3) theoretical errors 4) gross errors

6. The measure of accuracy is
1) absolute error 2) relative error
3) percentage error 4) both 2 and 3

7. The decrease in percentage error
1) increases the accuracy
2) does not effect the accuracy
3) decreases the accuracy
4) both 1 and 3

8. In a measurement, both positive and negative errors are found to occur with equal probability. The type of errors is
1) proportional errors 2) systematic errors
3) determinate errors 4) random errors

09. The errors that always occur in the measurement with screw gauge is
1) random errors 2) systematic errors
3) gross errors 4) negligible errors

10. A physicist performs an experiment and takes 200 readings.He repeats the same experiment and now takes 800 readings. By doing so
1) the probable error remains same
2) the probable error is four times
3) the probable error is halved
4) the probable error is reduced by a factor ¼

11. More the number of significant figures shows more the
1)accuracy 2)error 3)number of figures 4)value

12. If a measured quantity has n significant figures, the reliable digits in it are
1) n 2) n-1 3) $n+1$ 4) n/2

13. **If the significant figures are more,**
1)percentage error is more and accuracy is less
2)percentage error is less and accuracy is more
3)percentage error is less and accuracy is less
4)percentage error is more and accuracy is more

14. **The mathematical operation in which the accuracy is limited to least accurate term is**
1) addition 2) subtraction
3) multiplication & division 4) both 1 and 2

15. **The time period of a seconds pendulum is measured repeatedly for three times by two stop watches A,B. If the readings are as follows, then**

S.NO	A	B
1.	2.01 sec	2.56 sec
2.	2.10 sec	2.55 sec
3.	1.98 sec	2.57 sec

1) A is more accurate but B is more precise
2) B is more accurate but A is more precise
3) A,B are equally precise
4) A,B are equally accurate

16. **If Y = a + b, the maximum percentage error in the measurement of Y will be**
1) $\left(\frac{\Delta a}{a}+\frac{\Delta b}{b}\right)\times 100$ 2) $\left(\frac{\Delta a}{a+b}+\frac{\Delta b}{a+b}\right)\times 100$
3) $\left(\frac{\Delta a}{a}-\frac{\Delta b}{b}\right)\times 100$ 4) $\left(\frac{\Delta a}{a-b}-\frac{\Delta b}{a-b}\right)\times 100$

17. **If Y = a - b, the maximum percentage error in the measurement of Y will be**
1) $\left(\frac{\Delta a}{a}+\frac{\Delta b}{b}\right)\times 100$ 2) $\left(\frac{\Delta a}{a-b}+\frac{\Delta b}{a-b}\right)\times 100$
3) $\left(\frac{\Delta a}{a}-\frac{\Delta b}{b}\right)\times 100$ 4) $\left(\frac{\Delta a}{a-b}-\frac{\Delta b}{a-b}\right)\times 100$

18. **If Y = a x b, the maximum percentage error in the measurement of Y will be**
1) $\left(\frac{\Delta a}{a}\times 100\right)/\left(\frac{\Delta b}{b}\times 100\right)$ 2) $\left(\frac{\Delta a}{a}+\frac{\Delta b}{b}\right)\times 100$
3) $\left(\frac{\Delta a}{a}\times 100\right)\times\left(\frac{\Delta b}{b}\times 100\right)$ 4) $\left(\frac{\Delta a}{a}-\frac{\Delta b}{b}\right)\times 100$

19. **If Y = a/b, the maximum percentage error in the measurement of Y will be**
1) $\left(\frac{\Delta a}{a}\times 100\right)/\left(\frac{\Delta b}{b}\times 100\right)$ 2) $\left(\frac{\Delta a}{a}+\frac{\Delta b}{b}\right)\times 100$
3) $\left(\frac{\Delta a}{a}\times 100\right)\times\left(\frac{\Delta b}{b}\times 100\right)$
4) $\left(\frac{\Delta a}{a}-\frac{\Delta b}{b}\right)\times 100$

20. **Of the following the dimensionless error is**
1) Systematic error 2) Gross error
3) Random error 4) Relative error

21. **In determining viscosity (η) by the equation $\eta=\frac{\pi p r^4}{8vl}$ which of the quantities must be measured more accurately**
1) P 2) r 3) v 4) l

22. **The number of significant figures in 0.007** is
1) 4 2) 2 3) 3 4) 1

23. **Round off 20.96 to three significant figures**
1) 20.9 2) 20 3) 21.0 4) 21

UNITS AND DIMENSIONAL FORMULA

24. **The dimensional formula for strain energy density is**
1) $[M^1L^2T^{-3}]$ 2) $[M^1L^2T^3]$
3) $[M^1L^{-1}T^{-2}]$ 4) $[M^1L^2T^{-2}]$

25. **The dimensional formula for areal velocity is**
1) $[M^0L^{-2}T^{-1}]$ 2) $[M^0L^{-2}T^1]$
3) $[M^0L^2T^{-1}]$ 4) $[M^0L^2T^1]$

26. **The physical quantity having the same dimensional formula as that of force is**
1) Torque 2)work 3) pressure 4) thrust

27. **Nm^{-1} is the SI unit of**
1) velocity gradient 2) Rydberg's constant
3) coefficient of viscosity 4) Spring constant

28. **If P is the X-ray unit and Q is micron then P/Q is**
1) 10^{-5} 2) 10^5 3) 10^7 4) 10^{-7}

29. **The dimension of mass is zero in the following physical quantities.**
1)Surface tension 2)coefficient of viscosity
3)heat 4) Specific heat capacity

30. **The SI unit of a physical quantity is $[J\ m^{-2}]$. The dimensional formula for that quantity is**
1)$[M^1L^{-2}]$ 2)$[M^1L^0T^{-2}]$
3)$[M^1L^2T^{-1}]$ 4)$[M^1L^{-1}T^{-2}]$

31. **$[Jm^{-2}]$ is the unit of**
1) Surface tension 2) Viscosity
3) Strain energy 4) Intensity of energy

32. **The set of quantities which can form a group of fundamental quantities in any system of measurement is**
1) Length,mass and time
2)Length,mass and velocity
3)Length,velocity and time
4)velocity,mass and time

33. **The fundamental unit which is common in C.G.S. and S.I system is**
1) metre 2) second 3) gram 4) all the above

34. **1 a.m.u is equal to**
1) 1.66 x 10^{-24} g 2) 1.66 x 10^{-27} g
3) 1.66 x 10^{24} g 4) 1.66 x 10^{27} g

35. **Modulus of Elasticity is dimensionally equivalent to (1996 E)**
1) Stress 2) Surface tension
3) Strain 4)Coefficient of viscosity

36. **If x times momentum is work, then the dimensional formula of x is**
1)$[L^{1}T]$ 2)$[LT^{-1}]$ 3) $[ML^{-1}T^{-1}]$ 4) $[MLT^{1}]$

37. **The following does not give the unit of energy**
1) watt second 2) kilowatt hour
3) newton metre 4) pascal metre

38. **1 fermi is equal to**
1)$10^{-12}\,m$ 2) $10^{-9}\,m$ 3) 10^{-6} A^{0} 4)10^{-9} micron

39. **"Impulse per unit area " has same dimensions as that of**
1)coefficient of viscosity 2) surface tension
3) bulk modulus 4) gravitational potential

40. **The following pair does not have same dimensions**
1) Pressure, modulus of elasticity
2) Angular velocity, velocity gradient
3) Surface tension and force constant
4) Impulse and torque

41. **Dimensions of solar constant are**
1)$\left[M^{0}L^{0}T\right]$ 2)$\left[M^{1}L^{1}T^{-2}\right]$
3)$\left[M^{1}L^{-1}T^{-2}\right]$ 4)$\left[M^{1}T^{-3}\right]$

42. **The following is a unitless and dimensionless quantity**
1) Angle 2) Solid angle
3) Mechanical equivalent of heat
4) Coefficient of friction

43. **The unitless quantity is**
1) Velocity gradient 2) Pressure gradient
3) Displacement gradient 4) Force gradient

44. **If the unit of tension is divided by the unit of surface tension the derived unit will be same as that of**
1) Mass 2) Length 3) Area 4) Work

45. **Atto is ___________**
1) An instrument used to measure gradient
2) An instrument used to measure the altitude
3) 10^{18} 4) 10^{-18}

46. **N m s^{-1} is the unit of**
1) Pressure 2) Power
3) Potential 4) Pressure gradient

47. **Which one of the following represents the correct dimensions of the coefficient of viscosity? (AIEEE 2004)**
1) $[ML^{-1}T^{2}]$ 2) $[MLT^{-1}]$
3) $[ML^{-1}T^{-1}]$ 4) $[ML^{-2}T^{-2}]$

48. **Stefan's constant has the unit as**
1) J s^{-1} m^{-2} K^{4} 2) Kg s^{-3} K^{4}
3) W m^{-2} K^{-4} 4) Nms^{-2} K^{-4}

49. **Which one of the following is not measured in the units of energy**
1) (couple) x (angle turned through)
2) moment of inertia x (angular velocity)^{2}
3) force x distance 4) impulse x time

50. **An example to define length in the form of time at a place is**
1) Wrist watch 2) Linear expansion of iron rod
3) Frequency of ripples on the surface of water
4) Seconds pendulum

51. **The one which is not the unit of length is**
1) Angstrom unit 2) Micron
3) Par-sec 4) Steradian

52. **The physical quantity having the same dimensional formula as that of entropy is :**
1) Latent heat 2) Thermal capacity
3) Heat 4) Specific heat

53. **Js is the unit of**
1) Energy 2) Angular Momentum
3) Momentum 4) Power

54. **Which of the following cannot be expressed as dyne cm^{-2}?**
1) Pressure 2) Longitudinal stress
3) Longitudinal strain
4) Young's modulus of elasticity

55. **The unit of atmospheric pressure is :**
1) Metre 2) kgwt 3) g cm^{-2} 4) bar

56. **The ratio between pico and giga is**
1) 10^{21} 2) 10^{-21} 3) 10^{14} 4) 10^{8}

57. **1 micron =___ nanometer**
1) 10^{-6} 2)10^{-10} 3) 10^{3} 4) 10^{-3}

58. **Which of the following has smallest value?**
1) peta 2)femto 3) kilo 4)hecto

59. **The physical quantity having dimension 2 in length is**
1) Power 2) Acceleration
3) Force constant 4) Stress

60. **If m is the mass of drop of a liquid of radius 'r' then $\frac{mg}{\pi r}$ has the same dimensions of :**
1) Surface tension 2) Tension
3) Young's Modulus 4) Coefficient of viscosity

61. **The intensity of a wave is defined as the energy transmitted per unit area per second. Which of the following represents the dimensional formula for the intensity of the wave?**
1) $\left[ML^{0}T^{-2}\right]$ 2)$\left[ML^{0}T^{-3}\right]$
3)$\left[ML^{0}T^{-1}\right]$ 4) $[ML^{4}T]$

62. **The fundamental unit which has the same power in the dimensional formula of surface tension and coefficient of viscosity is(1989 E)**
1) mass 2) length 3) time 4) none

63. Electron volt is the unit of (1988 E)
1) Power 2) Potential difference
3) Charge 4) Energy

64. One shake is equal to
1) $10^{-8}s$ 2) $10^{-9}s$ 3) $10^{-10}s$ 4) $10^{9}s$

65. Torr is the unit of physical quantity
1) density 2) pressure
3) torque 4) None

66. The S.I. value of Mechanical equivalent of heat is:
1) 4.2 2) 1 3) 2.4 4) 2

67. The physical quantity that has no dimensions is:
1) angular velocity 2) linear momentum
3) angular momentum 4) strain

68. The physical quantities not having same dimensions are
1) torque and work
2) momentum and Planck's constant
3) stress and Young's modulus
4) speed and $\left(\mu_0 \in_o\right)^{-1/2}$

69. A pair of physical quantities having the same dimensional formula are (1992 M)
1) Force and Work 2) Work and energy
3) Force and Torque 4) Work and Power

70. The dimensional formula of calorie are
1) $[ML^2T^{-2}]$ 2) $[MLT^{-2}]$
3) $[ML^2T^{-1}]$ 4) $[MLT^{-1}]$

71. The dimensional formula for coefficient of kinematic viscosity is : (2002M)
1. $[M^0L^{-1}T^{-1}]$ 2. $[M^0L^2T^{-1}]$
3. $[ML^2T^{-1}]$ 4. $[ML^{-1}T^{-1}]$

72. The product of energy and time is called action. The dimensional formula for action is same as that for
1) force $\times$ velocity 2) impulse $\times$ distance
3) power 4) angular energy

73. Specific heat is in joule per kg per ^{0}C rise of temperature. Its dimensions are:
1) $[MLT^{-1}K^{-1}]$ 2) $[ML^2T^{-2}K^{-1}]$
3) $[M^0L^2T^{-2}K^{-1}]$ 4) $[MLT^{-2}K^{-1}]$

74. The dimensional formula for Magnetic Moment of a magnet is
1) $[M^0L^2T^0A^1]$ 2) $[M^0L^2T^0A^{-1}]$
3) $[M^0L^{-2}T^0A^{-1}]$ 4) $[M^0L^{-2}T^0A^1]$

75. Dimensions of C x R (Capacity x Resistance) is (1995 E)
1) frequency 2) energy
3) time period 4) current

76. Dimensional formula for capacitance is (1997E)
1) $[M^{-1}L^{-2}T^4I^2]$ 2) $[M^1L^2T^4I^{-2}]$
3) $[M^1L^2T^2]$ 4) $[MLT^{-1}]$

77. Of the following quantities which one has the dimensions different from the remaining three?
1) energy density 2) force per unit area
3) product of charge per unit volume and voltage
4) Angular momentum per unit mass

78. The dimensional formula of resistivity in terms of M, L, T and Q, where Q stands for the dimensions of charge is
1) $[ML^3T^{-1}Q^{-2}]$ 2) $[ML^3T^{-2}Q^{-1}]$
3) $[ML^2T^{-1}Q^{-1}]$ 4) $[MLT^{-1}Q^{-1}]$

79. The dimensional formula for Magnetic induction is (2000 M)
1) $[MT^{-1}A^{-1}]$ 2) $[MT^{-2}A^{-1}]$
3) $[MLA^{-1}]$ 4) $[MT^{-2}A]$

80. The dimensional formula for magnetic flux is (2003M)
1) $[ML^2T^{-2}I^{-1}]$ 2) $[ML^2T^{-2}I^{-2}]$
3) $[ML^{-2}T^{-2}I^{-1}]$ 4) $[ML^{-2}T^{-2}I^{-2}]$

81. The SI unit of a physical quantity having the dimensional formula of $[ML^0T^{-2}A^{-1}]$
1) tesla 2) weber
3) amp metre 4) amp m^2

82. What are the units of $\frac{\mu_0}{4\pi}$
1) $NA^{-1}m^2$ 2) NA^{-2}
3) Nm^2C^2 4) unitless

83. If μ is the permeability and $\in$ is the permittivity then $\frac{1}{\sqrt{\mu \in}}$ is equal to
1. speed of sound
2. speed of light in vacuum
3. speed of sound in medium
4. speed of light in medium

84. $\left[\frac{Permeability}{Permittivity}\right]$ will have the dimensional formula of :
1) $[M^0L^0T^0A^0]$ 2) $[M^2L^2T^4A^2]$
3) $[M^2L^4T^{-6}A^{-4}]$ 4) $[M^{-2}L^{-4}T^6A^4]$

85. Siemen is the S.I unit of (1991 E)
1) Electrical conductance 2) Electrical conductivity
3) Potential difference 4) Inductance

86. Which of the following quantities has the units Kg m^2 s^{-3} A^{-2}?
1) Resistance 2) Inductance
3) Capacitance 4) Magnetic flux

87. The SI unit of magnetic permeability is
1) Am^{-1} 2) Am^{-2} 3) Hm^{-2} 4) Hm^{-1}

88. The dimensions of time in Electrical intensity is
1) -1 2) -2 3) -3 4) 3

89. SI Unit of a physical quantity whose dimensional formula is $M^{-1}L^{-2}T^{4}A^{2}$ is
1.ohm 2. volt 3. siemen 4. farad

90. $\frac{1}{\sqrt{\text{Capacitance}\times\text{Inductance}}}$ have the same unit as
1) time 2) velocity
3)velocity gradient 4) none of the above

91. What are the units of $K=\frac{1}{4\pi\in_0}$? (AIEEE 2004)
1) $C^2N^{-1}m^{-2}$ 2) $C^{-2}N^1m^2$
3) $C^2N^1m^2$ 4) unitless

92. [$M^1L^2T^{-3}A^{-2}$] is the dimensional formula of :
1) electric resistance 2) capacity
3) electric potential 4) specific resistance

93. If L is the inductance, 'i' is current in the circuit, $\frac{1}{2}Li^2$ has the dimensions of
1. Work 2. Power 3. Pressure 4. Force

94. The dimension of length in electrical resistance is
1) 2 2) 1 3) -2 4) -1

95. If m is the mass, Q is the charge and B is the magnetic induction, *m/BQ* has the same dimensions as :(1999 M)
1)Frequency 2)Time 3)Velocity 4)Acceleration

96. If L has the dimensions of length, V that of potential and $\in_0$ is the permittivity of free space then quantity $\in_0 LV$ has the dimensions of
1) current 2) charge 3) resistance 4) voltage

97. Dimensional formula of 'ohm' is same as
1) $\frac{h}{e}$ 2) $\frac{h^2}{e}$ 3) $\frac{h}{e^2}$ 4) $\frac{h^2}{e^2}$

98. If 'm' is the mass of a body, 'a' is amplitude of vibration, and 'ω' is the angular frequency, $\frac{1}{2}ma^2\omega^2$ has same dimensional formula as
1) impulse 2) moment of momentum
3) moment of inertia 4) moment of force

99. If C, R, L and I denote capacity, resistance, inductance and electric current respectively, the quantities having the same dimensions of time are (2006 E)
a) CR b) L/R c) $\sqrt{LC}$ d) LI^2
1) a and b only 2) a and c only
3) a and d only 4) a, b and c only

100. Which of the following do not have the same dimensions as the other three? Given that *l* = length, m = mass, k= force constant, I = moment of inertia, B = magnetic induction, P_m = magnetic dipole moment, R= radius, g = acceleration due to gravity
1) $\sqrt{l/g}$ 2) $\sqrt{I/P_mB}$ 3) $\sqrt{k/m}$ 4) $\sqrt{R/g}$

101. Given that I= moment of inertia, P_m = magnetic dipole moment and B= magnetic induction, then the dimensional formula for I/P_mB is same as that of
1) time 2) length 3) $time^2$ 4) $length^2$

102. Given that m = mass, *l* = length, t = time and i = current. The dimensional formula of ml^2/t^3i are the same as that of
1) electric field 2) electric potential
3) capacitance 4) inductance

103. If F is the force, μ is the permeability, H is the intensity of magnetic field and i is the electric current, then $\frac{F}{\mu Hi}$ has the dimensions of
1) mass 2) length 3) time 4) energy

104. If $e, \in_0, h$ and c respectively represent electric charge, permittivity of free space, Planck's constant and speed of light then $\frac{e^2}{\in_0 hc}$ has the dimensions of
a) angle b) relative density
c) strain d) current
1) a & b are correct 2) d & c are correct
3) a, b & c are correct 4) a,b,c & d are correct

105. Two physical quantities are represented by P and Q. The dimensions of their product is [$M^2L^4T^{-4}I^{-1}$] and the dimensions of their ratio is [I^{-1}]. Then P and Q respectively are
1. magnetic flux and Torque acting on a magnet.
2. torque and Magnetic flux.
3. magnetic moment and Pole strength
4. magnetic moment and Magnetic permeability

C.U.Q-KEY

1) 2	2) 3	3) 4	4) 4	5) 2	6) 4
7) 1	8) 4	9) 2	10) 4	11) 1	12) 2
13) 2	14) 4	15) 1	16) 2	17) 2	18) 2
19) 2	20) 4	21) 2	22) 4	23) 3	24) 3
25) 3	26) 4	27) 4	28) 4	29) 4	30) 2
31) 1	32) 1	33) 2	34) 1	35) 1	36) 2
37) 4	38) 4	39) 1	40) 4	41) 4	42) 4
43) 3	44) 2	45) 4	46) 2	47) 3	48) 3
49) 4	50) 4	51) 4	52) 2	53) 2	54) 3
55) 4	56) 2	57) 3	58) 2	59) 1	60) 1
61) 2	62) 1	63) 4	64) 1	65) 2	66) 2
67) 4	68) 2	69) 2	70) 1	71) 2	72) 2
73) 3	74) 1	75) 3	76) 1	77) 4	78) 1
79) 2	80) 1	81) 1	82) 2	83) 4	84) 3
85) 1	86) 1	87) 4	88) 3	89) 4	90) 3
91) 2	92) 1	93) 1	94) 1	95) 2	96) 2
97) 3	98) 4	99) 4	100) 3	101) 3	102) 2
103) 2	104) 3	105) 1			

LEVEL-I (C.W)

ACCURACY, PRECISION, TYPES OF ERRORS AND COMBINATION OF ERRORS

1. The accuracy in the measurement of the diameter of hydrogen atom as 1.06 x 10^{-10} m is
1) 0.01 2) 106 x 10^{-10} 3) $\frac{1}{106}$ 4) 0.01 x 10^{-10}
2. The length of a rod is measured as 31.52 cm. Graduations on the scale are up to
1) 1 mm 2) 0.01 mm 3) 0.1 mm 4) 0.02 cm
3. If $L=(20\pm0.01)m$ and $B=(10\pm0.02)m$ then L/B is
1) $(2\pm0.03)m$ 2) $(2\pm0.015)m$
3) $(2\pm0.01)m$ 4) $(2\pm0.005)m$
4. The radius of a sphere is measured as $(10\pm0.02\%)cm$. The error in the measurement of its volume is
1) 25.1cc 2) 25.12cc 3) 2.51cc 4) 251.2cc
5. If length and breadth of a plate are (40 ± 0.2) cm and $(30\pm0.1)cm$, the absolute error in measurement of area is
1) $10cm^2$ 2) $8cm^2$ 3) $9cm^2$ 4) $7cm^2$
6. If the length of a cylinder is measured to be 4.28 cm with an error of 0.01 cm, the percentage error in the measured length is nearly
1) 0.4 % 2) 0.5 % 3) 0.2 % 4) 0.1 %
7. When 10 observations are taken, the random error is x. When 100 observations are taken, the random error becomes
1) x/10 2) x^2 3) 10 x 4) $\sqrt{x}$
8. If $L_1=(2.02\pm0.01)m$ and $L_2=(1.02\pm0.01)m$ then L_1+2L_2 is (in m)
1) 4.06 ± 0.02 2) 4.06 ± 0.03
3) 4.06 ± 0.005 4) 4.06 ± 0.01
9. A body travels uniformly a distance of $(20.0\pm0.2)m$ in time $(4.0\pm0.04)s$. The velocity of the body is
1) $(5.0\pm0.4)\ ms^{-1}$ 2) $(5.0\pm0.2)\ ms^{-1}$
3) $(5.0\pm0.6)\ ms^{-1}$ 4) $(5.0\pm0.1)\ ms^{-1}$

SIGNIFICANT FIGURES & ROUNDING OFF

10. If the value of 103.5 kg is rounded off to three significant figures, then the value is
1) 103 2) 103.0 3) 104 4) 10.3
11. The number of significant figures in $6.023\times10^{23}\ mole^{-1}$ is
1) 4 2) 3 3) 2 4) 23
12. The side of a cube is 2.5 metre. The volume of the cube to the significant figures is
1) 15 2) 16 3) 1.5 4) 1.6
13. When a force is expressed in dyne, the number of significant figures is four. If it is expressed in newton, the number of significant figures will become (10^5 dyne =1N)
1) 9 2) 5 3) 1 4) 4
14. $\sqrt{2.0}$ is
1) 1.414 2) 1.4 3) 1.0 4) 1
15. The mass of a box is 2.3 kg. Two marbles of masses 2.15 g and 12.48 g are added to it. The total mass of the box is
1) 2.3438 kg 2) 2.3428 kg
3) 2.34 kg 4) 2.31 kg
16. The number of significant figures in 0.010200 is
1) 6 2) 5 3) 3 4) 2
17. When the number 0.046508 is reduced to 4 significant figures, then it becomes
1) 0.0465 2) 4650.8 x 10^{-5}
3) 4.651 x 10^{-2} 4) 4.650 x 10^{-2}
18. With due regard to significant figures, the value of (46.7 – 10.04) is
1) 36.7 2) 36.00 3) 36.66 4) 30.6
19. The value of $\pi/53.2$ with due regard to significant figures is,
1) 0.0591 2) 0.0590 3) 0.590 4) 0.5906
20. By rounding off, a) 20.96 and b) 0.0003125 to 3 significant figures, we get
1) 21.0 ; 312 $\times10^{-4}$ 2) 21.0 ; 3.12 $\times10^{-4}$
3) 2.10 ; 3.12 $\times10^{-4}$ 4) 210; 3.12 $\times10^{-4}$

UNITS AND DIMENSIONAL FORMULAE

21. If the unit of length is doubled and that of mass and time is halved, the unit of energy will be
1) doubled 2) 4 times 3) 8 times 4) same
22. Given M is the mass suspended from a spring of force constant. k. The dimensional formula for $[M/k]^{1/2}$ is same as that for
1) frequency 2) time period
3) velocity 4) wavelength

23. The dimensional formula for the product of two physical quantities P and Q is [ML^2T^{-2}]. The dimensional formula of $\frac{P}{Q}$ is [MT^{-2}]. Then P and Q respectively are(2001 M)
1) Force and velocity
2) Momentum and displacement
3) Force and displacement
4) Work and velocity

24. The fundamental physical quantities that have same dimension in the dimensional formula of Torque and Angular Momentum are(2000 E)
1) mass, time 2) time, length
3) mass, length 4)time, mole

25. The physical quantity which has the dimensional formula as that of $\frac{energy}{mass \times length}$ is (2000 M)
1) Force 2) Power 3) Pressure 4) Acceleration

26. If J and E represent the angular momentum and rotational kinetic energy of a body, $\frac{J^2}{2E}$ represents the following physical quantity.
1) Moment of couple 2) Moment of force
3) Moment of inertia 4) Force

27. If the fundamental units of length, mass and time are doubled, the unit of force will
1) doubled 2)halved
3) remain same 4) four times

PRINCIPLE OF HOMOGENEITY

28. $\mu = A + \frac{B}{\lambda} + \frac{C}{\lambda^2}$ **is dimensionally correct. The dimensions of A, B and C respectively are (μ , A, B, C are constants) where λ is wave length of wave**
1)No dimensions, L, L^2 2)L^2, No dimensions, L
3) L, L^2, No dimensions 4)L, No dimensions, L^2

29. According to Bernoulli's theorem $\frac{p}{d} + \frac{v^2}{2} + gh =$ constant. The dimensional formula of the constant is (P is pressure, d is density, h is height, v is velocity and g is acceleration due to gravity) (2005 M)
1) [$M^0L^0T^0$] 2) [M^0LT^0]
3) [$M^0L^2T^{-2}$] 4) [$M^0L^2T^{-4}$]

CONVERSION OF UNITS

30. The surface tension of a liquid in CGS system is 45 dyne cm^{-1}. Its value in SI system is
1) 4.5 Nm^{-1} 2) 0.045 Nm^{-1}
3) 0.0045 Nm^{-1} 4) 0.45 Nm^{-1}

31. If minute is the unit of time, 10 ms^{-2} is the unit of acceleration and 100 kg is the unit of mass, the new unit of work in joule is
1) 10^5 2) 10^6 3) 6 x 10^6 4) 36x 10^6

32. The magnitude of force is 100 N. What will be its value if the units of mass and time are doubled and that of length is halved?
1) 25 2)100 3) 200 4) 400

33. A motor pumps water at the rate of V m^3 per second, against a pressure P Nm^{-2}. The power of the motor in watt is
1) PV 2) (P / V) 3) (V/P) 4) $(V - P)$

34. If the units of length and force are increased by four times the unit of energy will be increased by
1) 16% 2)1600% 3)1500% 4) 400%

35. SI unit and CGS unit of a quantity vary by 10^3 times, it is : (1994 E)
1) Boltzmann constant 2)Gravitational constant
3) Planck's constant 4) Angular Momentum

36. The value of universal gravitational constant G in CGS system is 6.67×10^{-8} dyne cm^2 g^{-2}. Its value in SI system is
1)6.67 x 10^{-11}Nm^2 kg^{-2} 2)6.67 x 10^{-5}Nm^2 kg^{-2}
3)6.67 x 10^{-10}Nm^2 kg^{-2} 4)6.67 x 10^{-9} Nm^2 kg^{-2}

TO CHECK THE CORRECTNESS OF PHYSICAL RELATION AND DERIVING THE EQUATIONS

37. The final velocity of a particle falling freely under gravity is given by $V^2 - u^2 = 2gx$ where x is the distance covered. If v = 18 kmph, g = 1000 cm s^{-2}, x = 120 cm then u = ----ms^{-1}.
1) 2.4 2) 1.2 3) 1 4) 0.1

38. The equation which is dimensionally correct among the following is
1) $v = u + at^2$ 2) $s = ut + at^3$
3) $s = ut + at^2$ 4) $t = s + av$

39. The dimensions of 'k' in the relation V = $k\ avt$ (where V is the volume of a liquid passing through any point in time t, 'a' is area of cross section, v is the velocity of the liquid) is
1) [$M^1L^2T^{-1}$] 2) [$M^1L^1T^{-1}$]
3) [$M^0L^0T^{-1}$] 4) [$M^0L^0T^0$]

40. If force (F), work (W) and velocity (V) are taken as fundamental quantities then the dimensional formula of Time (T) is (2007 M)
1) [$W^1F^1V^1$] 2) [$W^1F^1V^{-1}$]
3) [$W^{-1}F^{-1}V^{-1}$] 4) [$W^1F^{-1}V^{-1}$]

41. If Force F, Mass M and time T are chosen as fundamental quantities the dimensional formula for length, is

1)[FMT] 2)[$FM^{-1}T^2$] 3)[FL^2T^{-2}] 4)[$F^{-1}L^{-2}T^{-2}$]

42. If force F, Length L and time T are chosen as fundamental quantities,the dimensional formula for Mass is

1) [FLT] 2) [$F^{-1}L^{-1}T^{-2}$]
3) [$F^{-2}L^{-2}T^{-2}$] 4) [$F^1L^{-1}T^2$]

LEVEL-I(C.W)-KEY

01)3	02)3	03)4	04)3	05)1	06)3
07)1	08)2	09)4	10)3	11)1	12)2
13)4	14)2	15)4	16)2	17)3	18)1
19)2	20)2	21)3	22)2	23)3	24)3
25)4	26)3	27)3	28)1	29)3	30)2
31)4	32)1	33)1	34)3	35)2	36)1
37)3	38)3	39)4	40)4	41)2	42)4

LEVEL-I (C.W) - HINTS

1. $\frac{\Delta d}{d}=\frac{0.01\times10^{-10}}{1.06\times10^{-10}}=\frac{1}{106}$
2. $0.01cm$ is the least count of varnier caliperse.
3. $\frac{\Delta x}{x}=\frac{\Delta L}{L}+\frac{\Delta B}{B}\Rightarrow\Delta x=x\left[\frac{\Delta L}{L}+\frac{\Delta B}{B}\right]$

$=\frac{20}{10}\left[\frac{0.01}{20}+\frac{0.02}{10}\right]$

$x\pm\Delta x=(2\pm0.005)m$

4. $V=\frac{4}{3}\pi r^3\ \Rightarrow\ \frac{\Delta v}{v}\times100=3\frac{\Delta r}{r}\times100$

$\Delta v=3\times\frac{\Delta r}{r}\times v$

5. $A=lb\Rightarrow\frac{\Delta A}{A}=\frac{\Delta l}{l}+\frac{\Delta b}{b}\Rightarrow\Delta A=A\left[\frac{\Delta l}{l}+\frac{\Delta b}{b}\right]$

$\Delta A=b\Delta l+l\Delta b=10cm^2$

6. $\frac{\Delta l}{l}\times100=\frac{0.01}{4.28}\times100=0.2\%$
7. $X\alpha\frac{1}{N}\Rightarrow\frac{X_1}{X_2}=\frac{N_2}{N_1}=\frac{10}{100}$
8. $L_1+2L_2=2.02+2\times1.02=4.06$

$\Delta L_1+2\Delta L_2=0.01+2\times0.01=0.03$

9. $V=\frac{S}{T}\Rightarrow\frac{\Delta V}{V}=\frac{\Delta S}{S}+\frac{\Delta T}{T}$
10. If last digit is 5, if the preceding digit is odd then it should be increased by adding 1 and last digit 5 has to be ignored.
11. Use limitation of significant figures
12. $V=l^3$ and rounded off to minimum significant

From 13 to 20 follow the rules of significant figures and rounding off numbers

21. $\frac{E_2}{E_1}=\frac{M_2}{M_1}\left(\frac{L_2}{L_1}\right)^2\left(\frac{T_2}{T_1}\right)^{-2}$
22. Here [k] = force/ length = ML^0T^{-2}

Hence $\left[\frac{M}{k}\right]^{1/2}=M^0L^0T$

23. $PQ=ML^2T^{-2}$ ----(1); $\frac{P}{Q}=MT^{-2}$ -----(2)

(1) × (2) = $P^2=M^2L^2T^{-4}$

$\Rightarrow P=MLT^{-2}=FORCE$

(1) / (2) = $Q^2=L^2$

24. By dimensional formula
25. Substitute D.F. of quantities
26. $J\rightarrow ML^2T^{-1}$; $E\rightarrow ML^2T^{-2}$
27. $n_1u_1=n_2u_2$ 28. Substitute D.F. of quantities
29. Use principle of homogenity
30. $\frac{Dyne}{cm}=\frac{10^{-5}N}{10^{-2}m}=10^{-3}\frac{N}{m}$
31. $W\alpha Ma^2T^2$; $\frac{W_2}{W_1}=\frac{M_2a_2^2T_2^2}{M_1a_1^2T_1^2}$
32. $n_1[M_1L_1T_1^{-2}]=n_2[M_2L_2T_2^{-2}]$
33. Power αP^aV^b 34. Energy = Force x length
35. $n_1u_1=n_2u_2$
36. $6.67\times10^{-8}\ dyne\,cm^2\,(gm)^{-2}$

$=6.67\times10^{-8}\left(10^{-5}N\right)\left(10^{-2}m\right)^2\left(10^{-3}kg\right)^{-2}$

37. $v^2-u^2=2gx$ and change into S.I
38. Substitute D.F. of quantities
39. Substitute D.F. of quantities
40. $T\alpha F^xW^yV^z$; $M^0L^0T^1\alpha[MLT^{-2}]^x[ML^2T^{-2}]^y[LT^{-1}]^z$
41. $L\alpha F^aM^bT^c$ 42. $M\propto F^aL^bT^c$

LEVEL - I (H.W)

ACCURACY, PRECISION, TYPES OF ERRORS AND COMBINATION OF ERRORS

1. The Accuracy of a clock is one part in 10^{10}. The maximum difference between two such clocks operating for 10^{10} seconds is ______

1) 1 s 2) 5 s 3)10 s 4) 10^{10} s

2. The length of a rod is measured as 35.3 cm then the graduations on the scale are up to

1) 1 cm 2) 1 mm 3)0.01 mm 4)0.1 mm

3. **If** $L = 2.06cm \pm 0.02cm$, $B = 1.11cm \pm 0.03cm$, **then L+B equals to**
1) $3.17cm \pm 0.05cm$, 2) $2.06cm \pm 0.05cm$, 3) $3.17cm \pm 0.02cm$, 4) $3.17cm \pm 0.03cm$,

4. **The radius of sphere is measured as** (5.2 ± 0.2) **cm then the percentage error in volume of the ball is _**
1) 11% 2) 4% 3) 7% 4) 9%

5. **If the length and breadth of a plate are** (5.0 ± 0.2) **cm and** (4.0 ± 0.1)**cm then the absolute error in measurement of area is _**
1) $10cm^2$ 2) $11cm^2$ 3) $12cm^2$ 4) $1.3cm^2$

6. **If the length of a cylinder is measured to be 8.28 cm with an error of 0.01 cm then the percentage error in measured length is nearly**
1) 0.4 % 2) 0.2 % 3) 0.1 % 4) 0.5%

7. **A student performs experiment with simple pendulum and measures time for 10 vibrations. If he measures the time for 100 vibrations, the error in measurement of time period will be reduced by a factor of _**
1) 10 2) 90 3) 100 4) 1000

8. **If** $L_1 = (3.03 \pm 0.02)m$ **and** $L_2 = (2.01 \pm 0.02)m$ **then** $L_1 + 2L_2$ **is (in m)**
1) 7.05 ± 0.06 2) 6.05 ± 0.06 3) 6.05 ± 0.02 4) 7.05 ± 0.02

9. **A body travels uniformly a distance of** $(13.8 \pm 0.2)m$ **in a time** $(4.0 \pm 0.3)s$ **then the velocity of the body is ___**
1) $(3.45 \pm 0.2)ms^{-1}$ 2) $(3.45 \pm 0.3)ms^{-1}$ 3) $(3.45 \pm 0.4)ms^{-1}$ 4) $(3.45 \pm 0.5)ms^{-1}$

10. **The pressure on a square plate is measured by measuring the force on the plate and the length of the sides of the plate. If the maximum error in measurement of force and length are respectively 4% and 2% then the maximum error in Measurement of pressure is _____**
1) 1% 2) 2% 3) 6% 4) 8%

SIGNIFICANT FIGURES & ROUNDING OFF

11. **2.34 is obtained by rounding off the number**
1) 2.346 2) 2.355 3) 2.335 4) 2.334

12. **The number of significant figures in 0.0006032 is**
1) 7 2) 4 3) 5 4) 2

13. **The radius of disc is 1.2 cm, its area according to idea of significant figures is ___**
1) $4.5216cm^2$ 2) $4.521cm^2$ 3) $4.52cm^2$ 4) $4.5cm^2$

14. **When Energy is expressed in erg the no of significant figure is four. If it is expressed in joule the no of significant figures will become**
1) 9 2) 5 3) 1 4) 4

15. $\sqrt{58.97}$ **is**
1) 7.679 2) 7.68 3) 7.6 4) 7.7

16. **A stick has a length of 12.132 cm and another stick has a length of 12.4 cm then the total length of the stick is ___**
1) 24.53 cm 2) 24.5 cm 3) 2.45 cm 4) 2.453 cm

17. **The respective number of significant figures for the number 23.023, 0.0003 and 21 x 10^{-3} are**
1) 5,1,2 2) 5,1,5 3) 5,5,2 4) 4,4,2

18. **The Number of significant figures in** $5.69 \times 10^{15}\ kg$ **is**
1) 1 2) 2 3) 3 4) 4

19. **The value of 124.2 + 52.487 with due regard to significant places is ___**
1) 176.69 2) 176.7 3) 176 4) 177

20. **The value of** $\frac{9.27}{41}$ **with due regard to significant figures is ___**
1) 0.226 2) 0.23 3) 0.2 4) 0.2261

21. **When 57.986 is rounded off to 4 significant figures, then it becomes ___**
1) 58 2) 57.00 3) 57.90 4) 57.99

UNITS AND DIMENSIONAL FORMULAE

22. **If 'L' is length of simple pendulum and 'g' is acceleration due to gravity then the dimensional formula for** $\left(\frac{l}{g}\right)^{\frac{1}{2}}$ **is same as that for**
1) Frequency 2) Velocity 3) Time period 4) wavelength

23. **The dimensional formula for the product of two physical quantities P and Q is** $\left[L^2T^{-2}\right]$ **the dimensional formula of P/Q is** $\left[T^2\right]$ **the P and Q respectively are ___**
1) distance and velocity
2) distance and acceleration
3) displacement and velocity
4) displacement and force

24. **The fundamental physical quantities that have same dimensions in the dimensional formula of force and Energy are ___-**
1) mass, time 2) time, length
3) mass, length 4) time, mole

25. **If η is rigidity modulus, r is the radius, l is the length and C is the moment of the couple then $\frac{2lc}{\pi\eta r^4}$ has the dimensions of _**

1) Angle 2) Mass 3) Length 4) Frequency

PRINCIPLE OF HOMOGENEITY

26. **The acceleration of an object varies with time as $a = AT^2 + BT + C$ taking the unit of time as 1 sec and acceleration as ms^{-2} then the units of A,B,C respectively are __**

1) $ms^{-3}, ms^{-2}, ms^{-1}$ 2) ms^{-2}, ms^{-1}, ms
3) $ms^{-1}, ms^{-2}, ms^{-3}$ 4) $ms^{-4}, ms^{-3}, ms^{-2}$

27. **If $\eta = \frac{A}{B}\log(Bx + C)$ is dimensionally true, then (here η is the coefficient of viscosity and x is the distance)**

1) C is dimensionless constant
2) B has dimensions of -1 in length
3) The dimensional formula of A is $ML^{-2}T^{-1}$
4) All are true

28. **If the velocity (v) of a body in time 't' is given by $V = AT^3 + BT^2 + CT + D$ then the dimensions of C are ____**

1) $\left[LT^{-1}\right]$ 2) $\left[LT^{-2}\right]$ 3) $\left[LT^{-3}\right]$ 4) $\left[LT^{-4}\right]$

29. **In the relation $V = \frac{\pi pr^4}{8\eta l}$ where the letters have there usual meanings the dimensions of V are ___**

1) $M^0L^3T^0$ 2) $M^0L^3T^{-1}$
3) $M^0L^{-3}T^{-1}$ 4) $M^1L^3T^0$

30. **If the acceleration due to gravity is 10 ms^{-2} and the units of length and time are changed to kilometre and hour respectively the numerical value of acceleration is _____**

1) 36000 2) 72000 3) 36000 4) 129600

31. **The magnitude of Energy is 100J. What will be its value if the units of mass and time are doubled and that of length is halved?**

1) 100 J 2) 200 J 3) 400 J 4) 800 J

32. **If the units of mass and velocity are increased by two times then the unit of momentum will be increased by __**

1) 400% 2) 200% 3) 300% 4) 100%

33. **SI unit and CGS unit of a quantity vary by 10^7 times, it is ___**

1) Boltzmann's constant 2) Gravitational constant
3) Planck's constant 4) Angular momentum.

34. **The initial velocity of a particle is given by $u^2 = v^2 - 2gx$ where x is the distance covered. If u = 18 $km\,h^{-1}$, g = 1000 cm/s^2 x = 150 cm then v = ____ m/s**

1) $\sqrt{45}$ 2) $\sqrt{55}$ 3) $\sqrt{35}$ 4) $\sqrt{65}$

35. **The equation which is dimensionally correct among the following is**

1) $v = u + \frac{1}{2}at$ 2) $v = ut + at$
3) $s = ut + at^3$ 4) $t = s + av$

36. **The dimensions of γ in the relation $v = \sqrt{\frac{\gamma p}{\rho}}$ (where v is velocity, p is pressure, ρ is density)**

1) Dimensionless 2) $\left[LT^{-1}\right]$
3) $\left[ML^{-1}T^{-2}\right]$ 4) $\left[ML^{-3}\right]$

37. **Taking frequency f, velocity (v) and Density (ρ) to be the fundamental quantities then the Dimensional formula for momentum will be**

1) $\left(\rho v^4 f^{-3}\right)$ 2) $\left(\rho v^3 f^{-1}\right)$
3) $\left(\rho v f^2\right)$ 4) $\left(\rho^2 v^2 f^2\right)$

38. **If momentum (p), Mass (M), Time (T) are chosen as fundamental quantities then the dimensional formula for length is ___**

1) $\left(P^1T^1M^1\right)$ 2) $\left(P^1T^1M^2\right)$
3) $\left(P^1T^1M^{-1}\right)$ 4) $\left(P^2T^2M^1\right)$

39. **If pressure (P), velocity (V) and time (T) are taken as the fundamental quantities, then the dimensional formula of force is ___**

1) $\left[P^1V^1T^1\right]$ 2) $\left[P^1V^2T^1\right]$
3) $\left[P^1V^1T^2\right]$ 4) $\left[P^1V^2T^2\right]$

LEVEL-I (H.W) - KEY

01)1	02) 4	03) 1	04) 1	05)4	06)3
07)1	08) 1	09) 2	10)4	11)3	12)2
13)4	14)4	15) 1	16) 2	17)1	18)3
19)2	20)2	21)4	22)3	23)2	24)1
25)1	26)4	27)4	28)2	29)2	30)4
31)4	32)3	33)3	34)2	35)1	36)1
37)1	38)3	39)4			

LEVEL-I (H.W) - HINTS

1. $\frac{\Delta d}{d}$ 2) $0.01cm$ is the L.C of vernier caliperse.

3. Let x=L+B=3.17 ; $\Delta x = \Delta L + \Delta B = 0.05$

$\therefore x \pm \Delta x = 3.17 \pm 0.05$

4. $V = \frac{4}{3}\pi r^3$ & $\frac{\Delta V}{V}\times 100 = 3\frac{\Delta r}{r}\times 100$

5. $A = lb \Rightarrow \frac{\Delta A}{A} = \frac{\Delta l}{l} + \frac{\Delta b}{b} \Rightarrow \Delta A = A\left[\frac{\Delta l}{l} + \frac{\Delta b}{b}\right]$

6. $\frac{\Delta l}{l}\times 100$ 7. $\frac{X_1}{X_2} = \frac{N_2}{N_1}$

8. $x = L_1 + 2L_2 = 7.05$; $\Delta x = \Delta L_1 + 2\Delta L_2$

9. $V = \frac{S}{T} \Rightarrow \frac{\Delta V}{V} = \frac{\Delta S}{S} + \frac{\Delta T}{T}$; $\Delta V = V\left(\frac{\Delta S}{S} + \frac{\Delta T}{T}\right)$

10. $P = \frac{F}{A} = \frac{F}{L^2}$; $\frac{\Delta P}{P}\times 100 = \left(\frac{\Delta F}{F} + \frac{2\Delta L}{L}\right)(100)$

11. If last digit is 5 and if the preceding digit is odd then it should be increased by adding 1 and last digit 5 has to be ignored.

12. Use limitation of significant figures 13) $A = \pi r^2$

From 14 to 21 follow the rules of significant figures and rounding off numbers

22. Hence $\left[\frac{l}{g}\right]^{1/2} = \left[\frac{M^0 L^1 T^0}{M^0 L^1 T^{-2}}\right]^{1/2} = M^0 L^0 T^1$

23. $PQ = L^2 T^{-2}$ ----(1) ; $\frac{P}{Q} = T^2$ -----(2)

24. Use dimensional analysis
25. Using dimensional formula
26. Principle of homogenity
27. Using dimensional formula
28 & 29. Use principle of homogenity

30. $\left[a = LT^{-2}\right]$ 31. $E = \frac{ML^2}{T^2}$ 32. $P = MV$

33. $N_1U_1 = N_2U_2$ 34. $v^2 = u^2 + 2gx$

35. using dimensional analysis 36. $V = \sqrt{\frac{\gamma p}{\rho}}$

37. $P \propto f^a v^b \rho^c$; $MLT^{-1} = k\left[T^{-1}\right]^a\left[LT^{-1}\right]^b\left[ML^{-3}\right]^c$

38. $L \propto (P)^a (M)^b (T)^c$ 39. $F \propto P^a V^b T^c$

LEVEL - II (C.W)

ACCURACY, PRECISION, TYPES OF ERRORS AND COMBINATION OF ERRORS

1. The error in the measurement of the length of the simple pendulum is 0.2 % and the error in time period 4%. The maximum possible error in measurement of $\frac{L}{T^2}$ is

1) 4.2% 2) 3.8% 3) 7.8% 4) 8.2%

2. The least count of a stop watch is (1/5) s. The time of 20 oscillations of a pendulum is measured to be 25 s. The maximum percentage error in this measurement is

1) 8 % 2) 1 % 3) 0.8 % 4) 16 %

3. The diameter of a wire as measured by a screw gauge was found to be 1.002 cm, 1.004 cm and 1.006 cm. The absolute error in the third reading is

1) 0.002 cm 2) 0.004 cm
3) 1.002 cm 4) zero

4. Force and area are measured as 20 N and 5m^2 with errors 0.05 N and 0.0125m^2. The maximum error in pressure is (SI unit)

1) 4 ± 0.0625 2) 4 ± 0.05
3) 4 ± 0.125 4) 4 ± 0.02

5. The length and breadth of a rectangular object are 25.2cm and 16.8cm respectively and have been measured to an accuracy of 0.1cm. Relative error and percentage error in the area of the object are

1) 0.01 & 1% 2) 0.02 & 2%
3) 0.03 & 3% 4) 0.04 & 4%

SIGNIFICANT FIGURES & ROUNDING OFF

6. The velocity of light in vacuum is 30 crore m/s. This is expressed in standard form up to 3 significant figures as

1) 0.003 x 10^{11} m/s 2) 300 x 10^6 m/s
3) 3.00 x 10^8 m/s 4) 0.030 x 10^{10} m/s

7. The length, breadth and thickness of a rectangular lamina are 1.024 m, 0.56 m, and 0.0031 m. The volume is …………..m^3

1) 1.8 x 10^{-3} 2) 1.80 x 10^{-3}
3) 0.180 x 10^{-4} 4) 0.00177

8. The initial and final temperatures of a liquid are measured to be $(67.7 \pm 0.2)^0$ c and $(76.3 \pm 0.3)^0$ c then rise in temperature with error limit is

1) $(8.6 \pm 0.2)^0 C$ 2) $(8.6 \pm 0.3)^0 C$
3) $(8.6 \pm 0.5)^0 C$ 4) $(8.6 \pm 0.6)^0 C$

9. Less accurate of the four options given below

1) 9.27 2) 41 3) 1.01 4) 9.00×10^0

UNITS AND DIMENSIONAL FORMULAE

10. If the ratio of fundamental units in two systems is 1 :3, then the ratio of momenta in the two systems is

1) 1:3 2) 1:9 3) 1:27 4) 3:1

11. The velocity of the waves on the surface of water is proportional to $\lambda^{\alpha}\rho^{\beta}g^{\gamma}$ where λ =wave length, ρ = density and g = acceleration due to gravity. Which of the following relation is correct?
1) $\alpha = \beta \neq \gamma$ 2) $\beta = \gamma \neq \alpha$
3) $\gamma = \alpha \neq \beta$ 4) $\alpha \neq \beta \neq \gamma$

PRINCIPLE OF HOMOGENITY

12. The work done '*w*' by a body varies with displacement '*x*' as $w = Ax + \frac{B}{(C-x)^2}$. The dimensional formula for 'B' is
1. $[ML^2T^{-2}]$ 2. $[ML^4T^{-2}]$ 3. $[MLT^{-2}]$ 4. $[ML^2T^{-4}]$

CONVERSION OF UNITS

13. If the units of mass, time and length are 100 g, 20 cm and 1 minute respectively the equivalent energy for 1000 erg in the new system will be
1. 90 2. 900 3. 2 x 10^6 4. 300

14. The ratio of SI unit to the CGS unit of planck's constant is
1. 10^7:1 2. 10^4 :1 3. 10^6 :1 4. 1 :1

TO CHECK THE CORRECTNESS OF PHYSICAL RELATION & DERIVING THE EQUATIONS

15. The velocity of a body is expressed as V = $G^aM^bR^c$ where G is gravitational constant. M is mass, R is radius. The values of exponents a, b and c are :
1) $\frac{1}{2}, \frac{1}{2}, -\frac{1}{2}$ 2) 1, 1, 1 3) $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$ 4) $1, 1, \frac{1}{2}$

16. The velocity of a spherical ball through a viscous liquid is given by $v= v_0(1-e^{kt})$, where v_0 is the initial velocity and *t* represents time. If k depends on radius of ball (r), coefficient of viscosity (η) and mass of the ball (m), then
1) $k = mr/\eta$ 2) $k = \eta\, m/r$
3) $k = r\,\eta/m$ 4) $k = mr\eta$

17. Dimensional analysis of the equation $(\text{Velocity})^x = (\text{Pressure difference})^{\frac{3}{2}}.(\text{density})^{\frac{-3}{2}}$ gives the value of *x* as: (1986 E)
1) 1 2) 2 3) 3 4)-3

18. For the equation $F = A^a v^b d^c$ where F is force, A is area, v is velocity and d is density, with the dimensional analysis gives the following values for the exponents. (1985 E)
1) a=1, b = 2, c =1 2) a =2, b =1, c= 1
3)a =1, b =1, c= 2 4) a = 0, b =1 , c = 1

19. The length of pendulum is measured as 1.01m and time for 30 oscillations is measured as one minute 3 seconds. Error in length is 0.01 m and error in time is 3 secs. The percentage error in the measurement of acceleration due to gravity is. (Eng - 2012)
1) 1 2) 5 3) 10 4) 15

20. The dimensional formula of $\frac{1}{2}\mu_0H^2$ (μ_0 -permeability of free space and H-magnetic field intensity) is: (Eng - 2011)
1) MLT^{-1} 2) ML^2T^{-2} 3) $ML^{-1}T^{-2}$ 4) ML^2T^{-1}

21. If the force is given by $F = at + bt^2$ with t as time.The dimensions of a and b are (Eng-10)
1) MLT^{-4}, MLT^{-2} 2) MLT^{-3}, MLT^{-4}
3) ML^2T^{-3}, ML^2T^{-2} 4) ML^2T^{-3}, ML^3T^{-4}

22. When a wave traverses a medium, the displacement of a particle located at '*x*' at a time 't' is given by $y = a\sin(bt - cx)$, where a,b and c are constants of the wave, which of the following is a quantity with dimensions? (Eng - 2009)
1) y/a 2) bt 3) cx 4) b/c

23. The Energy (E), angular momentum (L) and universal gravitational constant (G) are chosen as fundamental quantities. The dimensions of universal gravitational constant in the dimensional formula of Planks constant (h) is (Eng - 2008)
1) 0 2) -1 3) 5/3 4) 1

24. If the absolute errors in two physical quantities A and B are a and b respectively, then the absolute error in the value of A-B is(Med- 2014)
1) a-b 2) b-a 3) $a \pm b$ 4) a+b

25. If the velocity *v* (in cm/s) of a particle is given in terms of time t (in sec) by the equation $v = at + \frac{b}{t+c}$, then the dimensions of a, b and c are (Med- 2011)

	a	b	c
1)	$[L^2]$	$[T]$	$[LT^2]$
2)	$[LT^2]$	$[LT]$	$[L]$
3)	$[LT^{-2}]$	$[L]$	$[T]$
4)	$[L]$	$[LT]$	$[T^2]$

26. A body weighs 22.42 g and has a measured volume of 4.7 cc the possible errors in the measurement of mass and volume are0.01g and 0.1 cc. Then the maximum percentage error in the density will be(Med- 2010)
1) 22% 2) 2.2% 3) 0.22% 4) 0.022%

27. If energy E, velocity v and time T are taken as fundamental quantities, the dimensional formula for surface tension is (Med-2009)

1) $\left[Ev^{-2}T^{-2}\right]$ 2) $\left[E^2vT^{-2}\right]$

3) $\left[Ev^{-2}T^{-1}\right]$ 4) $\left[E^{-2}v^{-2}T^{-1}\right]$

28. If power (p), surface tension (T) and Planck's constant (h) are arranged, so that the dimensions of time in their dimensional formulae are in ascending order, then which of the following is correct? (Med- 2008)

1) P. T, h 2) P, h, T 3) T, P, h 4) T, h, P

LEVEL-II (C.W) - KEY

1) 4	2) 3	3) 1	4) 4	5) 1	6) 3
7) 1	8) 3	9) 4	10) 1	11)3	12) 2
13) 1	14) 1	15) 1	16) 3	17) 3	18) 1
19) 3	20) 3	21) 2	22) 4	23) 1	24) 4
25) 3	26) 2	27) 1	28) 1		

LEVEL-II (C.W) - HINTS

1. Let $x=\dfrac{L}{T^2}$; $\dfrac{\Delta x}{x}=\dfrac{\Delta L}{L}+2\dfrac{\Delta T}{T}$

2. $\Delta T=\dfrac{1/5}{20}$ and $T=\dfrac{25}{20}$; $\%\ error=\dfrac{\Delta T}{T}\times 100$

3. $\Delta x_3=\left|x_3-x_{mean}\right|$

4. $P=\dfrac{F}{A}\Rightarrow\dfrac{\Delta P}{P}=\dfrac{\Delta F}{F}+\dfrac{\Delta A}{A}\Rightarrow\Delta P=P\left(\dfrac{\Delta F}{F}+\dfrac{\Delta A}{A}\right)$

5. $A=l\times b$; $\dfrac{\Delta A}{A}=\dfrac{\Delta l}{l}+\dfrac{\Delta b}{b}$

$$\frac{\Delta A}{A}\times 100=\left(\frac{\Delta l}{l}+\frac{\Delta b}{b}\right)\times 100$$

8. $\Delta t=t_2-t_1$

9. Less no. of significant figures represent less accuracy.

10. $\dfrac{M_1}{M_2}=\dfrac{L_1}{L_2}=\dfrac{T_1}{T_2}=\dfrac{1}{3}$; $\left(\dfrac{P_1}{P_2}\right)=\left(\dfrac{M_1}{M_2}\right)\left(\dfrac{L_1}{L_2}\right)\left(\dfrac{T_1}{T_2}\right)^{-1}$

11. $v\propto\lambda^\alpha\rho^\beta g^\gamma$; $LT^{-1}=L^\alpha M^\beta L^{-3\beta}L^\gamma T^{-2\gamma}$. Comparing the powers on both sides, we get α,β and γ

12. $w=Ax+\dfrac{B}{(C-x)^2}$ (principle of homogenity)

13. $n_1[M_1L_1^{\,2}T_1^{\,-2}]=n_2[M_2L_2^{\,2}T_2^{\,-2}]$

14. $h=ML^2T^{-1}$ 15. $[LT^{-1}]\alpha\left[M^{-1}L^3T^{-2}\right]^a M^bL^c$

16. $k\alpha r^a\eta^b m^c$; $T^{-1}\alpha L^a\left[ML^{-1}T^{-1}\right]^b M^c$

17. Substitute dimension formulae

18. F = $A^av^bd^c$; $MLT^{-2}=\left(L^2\right)^a\left(LT^{-1}\right)^b\left(ML^{-3}\right)^c$ comparing the powers on both sides

19. $T=2\pi\sqrt{\dfrac{l}{g}}$; $\dfrac{\Delta g}{g}\times 100=\dfrac{\Delta l}{l}\times 100+2\dfrac{\Delta T}{T}\times 100$

20. Substitute dimensional formula of $_0$ and H

21. $MLT^{-2}=at$; $MLT^{-2}=bt^2$

22. by dimensional formulae

23. $h\propto E,L,G$

$$ML^2T^{-1}=\left(ML^2T^{-2}\right)^a\left(ML^2T^{-1}\right)^b\left(M^{-1}L^3T^{-2}\right)^c$$

Comparing the powers on both sides we get a,b,c

24. If $Z=A-B$; $\Delta Z=\Delta A+\Delta B$ (Max possible error) $\Delta Z=a+b$

25. Use principal of homogenity

26. The density of $d=\dfrac{M}{V}$; % Error of density

$$\frac{\Delta d}{d}\times 100=\frac{\Delta M}{M}\times 100+\frac{\Delta V}{V}\times 100$$

27. $[S]\propto[E]^a\times[v]^b\times[T]^c$

$$\left[MT^{-2}\right]=\left[ML^2T^{-2}\right]^a\times\left[LT^{-1}\right]^b\times[T]^c$$

Comparing the powers on both sides we get a,b,c

28. Use dimensional analysis

LEVEL - II (H.W)

ACCURACY, PRECISION, TYPES OF ERRORS AND COMBINATION OF ERRORS

1. The error in the measurement of length of a simple pendulum is 0.1 % and error in the time period is 2% . The possible maximum error in the quantity having dimensional formula LT^{-2} is

1) 1.1 % 2) 2.1 % 3) 4.1 % 4) 6.1 %

2. The length of a cylinder is measured as 5cm using a vernier calipers of least count 0.1mm. The percentage error in the measured length is nearly

1) 0.5 % 2) 2 % 3) 20 % 4) 0.2 %

3. **The diameter of a wire as measured by a screw gauge was found to be 1.002 cm, 1.000cm, 1.006cm, the absolute error in the first reading.**
1) 0.001cm 2)0.004 cm 3)0.006m 4)0.003cm

4. **The number of particles crossing per unit area perpendicular to x-axis in unit time is $N=-D\left(\frac{n_2-n_1}{x_2-x_1}\right)$ Where n_1 and n_2 are number of particles per unit volume for the value of x_1 and x_2 respectively.The dimension of diffusion constant D is**
1) $M^0L^1T^2$ 2) $M^0L^2T^{-4}$ 3) $M^0L^1T^{-3}$ 4) $M^0L^2T^{-1}$

5. **The external and internal diameters of a hollow cylinder are determined with vernier calipers and the results are recorded as $(4.23\pm0.001)cm$ and $(3.89\pm0.01)cm$. The thickness of the cylinder wall within the limits of error is**
1) 0.34 ± 0.01 cm 2) 0.34 ± 0.02 cm
3) 0.34 ± 0.04 cm 4) 0.17 ± 0.01 cm

6. **The density of a cube can be measured by measuring its mass and the length of its side. If the maximum errors in the measurement of mass and length are 3% and 2% respectively, the maximum error in the measurement of the density of the cube is**
1) 9% 2) 19% 3) 10% 4) 90%

7. **the diameter of a sphere is 3.34m Calculate its volume with due regard to significant figures (in m^3) .**
1)19.5169 2)9.516 3)19.5 4) 19.51

8. **The length, breadth and thickness of a metal sheet are 4.234 m, 1.005m, and 2.01 cm respectively then the volume of the sheet is**
1) 0.08 m^3 2) 0.0855 m^3
3)0.085 m^3 4) 0.087 m^3

9. **The sides of rectangle are (10.5 ± 0.2) cm and (5.2 ± 0.1) cm then its perimeter with error limit.**
1) (31.4 ± 0.6) cm 2) (31.4 ± 0.2) cm
3) (31.4 ± 0.1) cm 4) (31.4 ± 0.9) cm

10. **If the ratio of fundamental units in two systems are 2:3 the ratio of force in these two systems is**
1) 1:3 2) 1:1 3) 3:1 4) 1:27

11. **If L, R, C, and V, respectively, represent inductance, resistance, capacitance and potential difference, then the dimensions of L/RCV are the same as those of**
1) Charge 2)1/Charge 3)Current 4)1/Current

12. **Hydrostatic pressure 'P' varies with displacement 'x' as $P=\frac{A}{B}\log\left(Bx^2+C\right)$ where A, B and C are constants. The dimensional formula for 'A' is**
1) $[M^1L^{-1}T^{-2}]$ 2) $[MLT^{-2}]$
3) $[ML^{-2}T^{-2}]$ 4) $[ML^{-3}T^{-2}]$

13. **The units of force, velocity and energy are 100 dyne, 10 cm s^{-1} and 500 erg respectively. The units of mass, length and time are**
1) 5 g, 5 cm, 5 s 2) 5 g, 5 cm, 0.5 s
3) 0.5 g, 5 cm, 5 s 4) 5 g, 0.5cm, 5 s

14. **The ratio of SI unit to CGS unit of gravitational constant is**
1) $1:10^3$ 2) $10^3:1$ 3) 1:1 4) $1:10^7$

15. **The frequency f of vibrations of a mass m suspended from a spring of spring constant k is given by $f=Cm^xK^y$, where C is a dimensionless constant. The values of x and y are, respectively.**
1) $\frac{1}{2},\frac{1}{2}$ 2) $-\frac{1}{2},-\frac{1}{2}$ 3) $\frac{1}{2},-\frac{1}{2}$ 4) $-\frac{1}{2},\frac{1}{2}$

16. **If the time period 'T' of a drop under surface tension 's' is given by T = $\sqrt{d^a r^b s^c}$ where d is the density, r is the radius of the drop. If a =1, c = -1 then the value of b is (1993 E)**
1) 1 2) 2 3) 3 4) -1

17. **If the velocity (V), acceleration (A), and force (F) are taken as fundamental quantities instead of mass (M), length (L), and time (T), the dimensions of Young's modulus (Y) would be.**
1) FA^2V^{-4} 2) FA^2V^{-5} 3) FA^2V^{-3} 4) FA^2V^{-2}

18. **The time dependence of a physical quantity P is given by $P=P_0e^{-\alpha t^2}$, where α is a constant and t is time. Then constant α**
1)is dimensionless 2)has dimensions of T^{-2}
3)has dimensions of P 4)has dimensions of T^2

19. **The value of x in the formula $Y=\frac{2mgl^x}{5bt^3e}$ where m is the mass, 'g' is acceleration due to gravity, l is the length, 'b' is the breadth, 't' is the thickness and e is the extension and Y is Young's Modulus, is**
1) 3 2) 2 3) 1 4) 4

20. **The velocity of sound in air (V) pressure (P) and density of air (d) are related as $V\alpha p^xd^y$. The values of x and y respectively are**
1) $1,\frac{1}{2}$ 2) $-\frac{1}{2},-\frac{1}{2}$ 3) $\frac{1}{2},\frac{1}{2}$ 4) $\frac{1}{2},-\frac{1}{2}$

LEVEL-II (H.W) - KEY

1) 3	2) 4	3) 1	4) 4	5) 4	6) 1
7) 3	8) 2	9) 1	10) 2	11)4	12)4
13)2	14) 1	15) 4	16) 3	17)1	18)2
19) 1	20) 4				

LEVEL-II (H.W) - HINTS

1. $\frac{\Delta L}{L}+2\frac{\Delta T}{T}$ 2. $\frac{\Delta l}{l}\times 100$

3. $a_{mean}=\frac{a_1+a_2+a_3}{3}$; $\Delta a_3=\left|a_{mean}-a_3\right|$

5. $t=\frac{d_2-d_1}{2}$; $\Delta t=\Delta t_2+\Delta t_1$

6. $d=\frac{M}{V}=\frac{M}{L^3}$; $\frac{\Delta d}{d}\times 100=\left(\frac{\Delta M}{M}+\frac{3\Delta L}{L}\right)100$

7. $V=\frac{4}{3}\pi R^3$ 8. $V=lbw$

9. $p=2(l+b)=\Delta p=2(\Delta l+\Delta b)$

10. $\frac{M_1}{M_2}=\frac{L_1}{L_2}=\frac{T_1}{T_2}=\frac{2}{3}$ and $\frac{F_1}{F_2}=\frac{M_1L_1T_1^{-2}}{M_2L_2T_2^{-2}}$

11. $\frac{L}{RCV}=\frac{L}{t\left(L.\frac{di}{dt}\right)}$

12. $Bx^2+C=$ Constant ; $BL^2=M^0L^0T^0$; $P=\frac{A}{B}$

13. $F=MLT^{-2}=100$ dyne ;
$V=LT^{-1}=10\,cm/\sec$; $E=ML^2T^{-2}$

14. $n\propto\frac{1}{u}\Rightarrow n_1u_1=n_2u_2$ 15. $f=\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

16. $T=\sqrt{\left(ML^{-3}\right)^a.L^b\left(MT^{-2}\right)^c}$

17. $Y\propto V^aA^bF^c$; $\left(ML^{-1}T^{-2}\right)=\left(LT^{-1}\right)^a\left(LT^{-2}\right)^b\left(MLT^{-2}\right)^c$

18. $\alpha t^2=M^0L^0T^0$

19. Dimensional formula of $Y=ML^{-1}T^{-2}$
Dimension of L,b,t,e=L

20. $V=\sqrt{\frac{\gamma p}{d}}$; $LT^{-1}=V$

LEVEL - III

ACCURACY, PRECISION, TYPES OF ERRORS AND COMBINATION OF ERRORS

1. **The measured mass and volume of a body are 53.63 g and 5.8 cm³ respectively, with possible errors of 0.01 g and 0.1 cm³. The maximum percentage error in density is about**
1) 0.2% 2) 2% 3) 5% 4) 10%

2. **A vernier calipers has 1 mm marks on the main scale . It has 20 equal divisions on the vernier scale,which match with 16main scale divisions. For this vernier calipers the least count is**
1) 0.02mm 2) 0.05 mm 3) 0.1mm 4) 0.2mm

3. **The resistance of metal is given by V=IR. The voltage in the resistance is $V=(8\pm 0.5)$ V and current in the resistance is $I=(2\pm 0.2)$ A, the value of resistance with its percentage error is**
1) $(4\pm 16.25\%)\Omega$ 2) $(4\pm 2.5\%)\Omega$
3) $(4\pm 0.04\%)\Omega$ 4) $(4\pm 1\%)\Omega$

4. **In an experiment, the values of refractive indices of glass were found to be 1.54, 1.53, 1.44, 1.54, 1.56 and 1.45 in successive measurements i) mean value of refractive index of glass ii) mean absolute error iii) relative error and iv) percentage error are respectively,**
1)1.51,0.04,0.03,3% 2)1.51,0.4,0.03,3 %
3)15.1,0.04,0.03,3% 4)15.1,0.04,0.3,3 %

5. **A student performs an experiment for determination of $g\left[=\frac{4\pi^2L}{T^2}\right]$,L ≈ 1m, and he commits an error of ΔL for T he tajes the time of n oscillations with the stop watch of least count ΔT .For which of the following data the measurement of g will be most accurate?**
1) $\Delta L=0.5,\Delta T=0.1,n=20$
2) $\Delta L=0.5,\Delta T=0.1,n=50$
3) $\Delta L=0.5,\Delta T=0.01,n=20$
4) $\Delta L=0.5,\Delta T=0.05,n=50$

6. **A rectangular metal slab of mass 33.333 has its length 8.0 cm, breadth 5.0 cm and thickness 1mm. The mass is measured with accuracy up to 1 mg with a sensitive balance. The length and breadth are measured with vernier calipers having a least count of 0.01 cm. The thickness is measured with a screw gauge of least count 0.01 mm. The percentage accuracy in density calculated from the above measurements is**
1) 13 % 2)130 % 3)1.6 % 4)16 %

7. **The initial and final temperatures are recorded as $(40.6\pm 0.3)^0C$ and $(50.7\pm 0.2)^0C$. The rise in temperature is**
1) 10.1^0 C 2) $(10.1\pm 0.3)^0C$
3) $(10.1\pm 0.5)^0C$ 4) $(10.1\pm 0.1)^0C$

8. In the measurement of a physical quantity $X = \frac{A^2 B}{C^{1/3} D^3}$. The percentage errors introduced in the measurements of the quantities A,B,C and D are 2%, 2%, 4% and 5% respectively. Then the minimum amount of percentage of error in the measurement of X is contributed by
1) A 2) B 3) C 4) D

9. There are atomic (Cesium) clocks capable of measuring time with an accuracy of 1 part in 10^{11}. If two such clocks are operated to precision, then after running for 5000 years, these will record a difference of
1) 1 day 2) 1 s 3) 10^{11} s 4) 1year

10. If the length of a simple pendulum is recorded as (90.0 ± 0.02) cm and period as (1.9 ± 0.02) s, the percentage of error in the measurement of acceleration due to gravity is
1) 4.2 2) 2.1 3) 1.5 4) 2.8

11. In the determination of the Young's modulus of a given wire, the force, length, radius and extension in the wire are measured as $(100 \pm 0.01)N$, $(1.25 \pm 0.002)m$, $(0.001 \pm 0.00002)m$, and $(0.01 \pm 0.00002)m$, respectively. The percentage error in the measurement of Young's modulus is
1) 4.37 2) 2.37 3) 0.77 4) 2.77

12. The radius (r), length (l) and resistance (x) of a thin wire are $(0.2 \pm 0.02)cm$, $(80 \pm 0.1)cm$, and $(30 \pm 1)\Omega$ respectively. The percentage error in the specific resistance is
1) 23.4% 2) 25.4% 3) 26% 4) 27.5 %

13. When a current of (2.5 ± 0.5) ampere flows through a wire, it develops a potential difference of (20 ± 1) volt, the resistance of the wire is
1) $(8 \pm 2)\Omega$ 2) $(10 \pm 3)\Omega$
3) $(18 \pm 4)\Omega$ 4) $(20 \pm 6)\Omega$

14. Two objects A and B are of lengths 5 cm and 7 cm determined with errors 0.1 cm and 0.2 cm respectively. The error in determining (a) the total length and (b) the difference in their lengths are
1) $(12 \pm 0.3),(2 \pm 0.3)$ 2) $(7 \pm 0.3),(2 \pm 0.3)$
3) $(12 \pm 0.3),(12 \pm 0.3)$ 4) $(12 \pm 0.3),(2 \pm 0.6)$

15. In a simple pendulum experiment, length is measured as 31.4 cm with an accuracy of 1mm. The time for 100 oscillations of pendulum is 112 s with an accuracy of 0.01s. The percentage accuracy in g is
1) 1 2) 2.8 3) 1.3 4) 2.1

SIGNIFICANT FIGURES

16. Three pieces of silver have masses 2.3 kg, 41.15 g and 30.19 g. The total mass of correct significant figures is (in kg)
1) 2.37032 2) 2.370 3) 2.37 4) 2.4

17. The sum of the given two numbers with regard to significant figures is
$\left(5.0 \times 10^{-8}\right) + \left(4.5 \times 10^{-6}\right) =$
1) 4.55×10^{-6} 2) 4.5×10^{-6}
3) 4.6×10^{-6} 4) 4×10^{-6}

18. The dimensions of a wooden block are $1.1m \times 2.36m \times 3.1m$. The number of significant figures in its volume should be
1) 1 2) 2 3) 3 4) 4

PRINCIPLE OF HOMOGENITY

19. In the relation $P = \frac{\alpha}{\beta} e^{-\alpha z / K\theta}$; P is pressure, K is Boltzmann's constant, Z is distance and θ is temperature. The dimensional formula of β will be
1) $\left[M^0 L^2 T^0\right]$ 2) $\left[M^1 L^2 T^1\right]$
3) $\left[M L^0 T^{-1}\right]$ 4) $\left[M^0 L^2 T^{-1}\right]$

20. The Richardson equation is given by $I = AT^2 e^{-B/kT}$. The dimensional formula for AB^2 is same as that for A and B are constants
1) IT^{-2} 2) k T 3) Ik^2 4) Ik^2/T

21. The heat generated in a circuit is given by Q = i² Rt joule , where 'i' is current, R is resistance and t is time. If the percentage errors in measuring i, R and t are 2%, 1% and 1% respectively, the maximum error in measuring heat will be
1) 2 % 2) 3 % 3) 4 % 4) 6 %

LEVEL - III -KEY

1)2	2)4	3)1	4)1	5)4	6)3
7)3	8)3	9)2	10)2	11)1	12)1
13)1	14)1	15)4	16)4	17)3	18)2
19)1	20)3	21)4			

LEVEL - III - HINTS

1. Density $\rho = \frac{M}{V}$; $\frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta M}{M} + \frac{\Delta V}{V}\right] 100$

2. 16 M.S.D = 20 V.S.D $\Rightarrow 1 V.S.D = 4/5 M.S.D$
L.C = 1M.S.D - 1 V.S.D

3. $R=\frac{V}{I}$; $100\times\frac{\Delta R}{R}=\left[\frac{\Delta V}{V}+\frac{\Delta I}{I}\right]\times 100$

Resistance $=\left[R\pm\frac{\Delta R}{R}\times 100\right]$

4. $\mu_{mean}=\frac{\sum\mu}{6};\Delta\mu_{mean}=\frac{\sum(\mu_{mean}-\mu_i)}{6}$;

relative % error in $\mu=\frac{\Delta\mu_{mean}}{\mu_{mean}}\times 100$

5. $\frac{\Delta g}{g}=\frac{\Delta l}{l}+2\frac{\Delta T}{T}$ (Δl and ΔT are least, and the number of readings are maximum)

6. Percentage error gives percentage accuracy $d=\frac{m}{lbh}$

relative error, $\frac{\Delta d}{d}=\frac{\Delta m}{m}+\frac{\Delta l}{l}+\frac{\Delta b}{b}+\frac{\Delta h}{h}$

and calculate $\left(\frac{\Delta d}{d}\right)\times 100$

7. $t_2-t_1=(50.7-40.6)\pm(0.3+0.2)$

8. $\frac{\Delta X}{X}\times 100=2\frac{\Delta A}{A}\times 100+\frac{\Delta B}{B}\times 100$

$+\frac{1}{3}\frac{\Delta C}{C}\times 100+\frac{3\Delta D}{D}\times 100$

09. $\Delta t=5000\times\frac{1}{10^{11}}$ years rounded off to minimum significant figures

10. $g=4\pi^2\frac{l}{T^2}$; $\frac{\Delta g}{g}\times 100=\frac{\Delta l}{l}\times 100+\frac{2\Delta T}{T}\times 100$

11. $Y=\frac{FL}{Ae}=\frac{FL}{\pi r^2 e}$; $\frac{\Delta Y}{Y}\times 100=\left[\frac{\Delta F}{F}+\frac{\Delta L}{L}+\frac{2\Delta r}{r}+\frac{\Delta e}{e}\right]\times 100$

12. Specific Resistance $\rho=\frac{\pi r^2 x}{L}$

Total % error is $\left[\frac{2\Delta r}{r}+\frac{\Delta L}{L}+\frac{\Delta x}{x}\right]\times 100$

13. $R\pm\Delta R=\frac{V}{I}+\left[\frac{\Delta V}{V}+\frac{\Delta I}{I}\right]R$

14. $x=(a+b)$ and $\Delta x=\Delta a+\Delta b$

$x=(a-b)$ and $\Delta x=\Delta a+\Delta b$

15. $g=4\pi^2\frac{l}{T^2}$; $\frac{\Delta g}{g}\times 100=\frac{\Delta l}{l}\times 100+\frac{2\Delta T}{T}\times 100$

From 16 to 18 follow the rules of significant figures and rounding off numbers

19. $\left[\frac{\alpha z}{k\theta}\right]=1$; 20)Here $[A]=IT^{-2}$ and $[B]=KT$

21. $Q=i^2Rt$; $\frac{\Delta Q}{Q}\times 100=\frac{2\Delta i}{i}\times 100+\frac{\Delta R}{R}\times 100+\frac{\Delta t}{t}\times 100$

LEVEL - IV

Matching Questions

1.

Column-I	Column-II
a) Backlash error	p) Always subtracted
b) Zero error	q)Least count =1M.S.D-1V.S.D
c) Vernier callipers	r) May be -ve or +ve
d) Error in screw gauge	s) Due to loose fittings

2. There are four vernier scales, whose specification are given in column-I and the least count is given in column-II (S=value of main scale division,n=number of marks on vernier)

Column-I	Column-II
a) S=1 mm ,n=10	p) 0.05 mm
b) S=0.5mm,n=10	q) 0.01 mm
c) S=0.5 mm,n=20	r) 0.1 mm
d) S=1 mm , n=100	s) 0.025 mm

3. Using signification figures, match the following

Column-I	Column-II
a) 0.12345	p) 5
b) 0.1210 cm	q) 4
c) 47.23/2.3	r) 3
d) 3×10^8	s) 2
	t) 1

4. Match List I with List II and select the correct answer using the codes given below the Lists.

	List - I	List - II
A)	Distance between earth and stars	I) Micron
B)	Inter atomic distance in a solid	II) angstrom
C)	Size of the nucleus	III) Light year
D)	Wave length of infrared laser	IV) fermi
		V) kilometre

5. Some physical constants are given in List - I and their dimensional formulae are given in List- 2.Match the following (2007 E)

List - I	List - II
a) Planck's constant	e) $\left[ML^{-1}T^{-2}\right]$
b) Gravitational constant	f) $\left[ML^{-1}T^{-1}\right]$
c) Bulk modulus	g) $\left[ML^2T^{-1}\right]$
d) Coefficient of Viscosity	h) $\left[M^{-1}L^3T^{-2}\right]$

6. Names of units of some physical quantities are given in List - I and their dimensional formulae are given in List - II. Match the correct pair of the lists. (2005 E)

List - I	List - II
a) Pa s	e) $\left[L^2T^{-2}K^{-1}\right]$
b) NmK^{-1}	f) $\left[MLT^{-3}K^{-1}\right]$
c) $J\,kg^{-1}K^{-1}$	g) $\left[ML^{-1}T^{-1}\right]$
d) $Wm^{-1}K^{-1}$	h) $\left[ML^2T^{-2}K^{-1}\right]$

7. **Match List I with List II and select the correct answer using the codes given below the lists.**

List - I	**List - II**
a) joule	e) henry amp/s
b) watt	f) farad volt
c) volt	g) coulomb volt
d) coulomb	h) oersted cm
	i) ampere gauss
	j) $(\text{ampere})^2$ ohm

8. **Match List I with List II and select the correct answer using the codes given below the lists.**

List - I	**List - II**
a) Same negative dimensions of mass	I) pressure, Rydberg's constant
b) same negative dimensions of length	II) Magnetic induction field,potential
c) same dimensions of time	III) Capacity, universal gravitational constant
d) Same dimension of current	IV) Energy density, surface tension

Assertion & Reasoning Questions

Options :

1. A and R are correct and R is correct explanation of A

2. A and R are correct and R is not correct explanation of A

3. A is true and R is false

4. Both A and R are false

9. **Assertion(A) :** The equation y = x + t cannot be true where x,y are the distances and t is time
Reason(R) : quantities with different dimensions can not be added

10. **Assertion(A) :** Plane angle is dimensionless quantity.
Reason(R) : All unitless quantities are dimensionless

11. **Assertion(A) :** Dimensions of constant of proportionality of constants can be derived from dimensional method
Reason(R) : Numerical value of constant of proportionality can be found from experiments only

12. **Assertion(A) :** Solid angle is dimensionless quantity and it is a supplementary quantity.
Reason(R) : All supplementary quantities are dimensionless.

13. **Assertion(A) :** When we change the unit of measurement of a quantity, its numerical value changes.
Reason(R) : Smaller the unit of measurement, smaller is its numerical value.

14. **Assertion(A) :** If u_1 *and* u_2 are units and n_1, n_2 are their numerical values in two different systems then $n_1 > n_2 \Rightarrow u_1 < u_2$.
Reason(R) : The numerical value of physical quantity is inversely proportional to unit.

15. **Assertion(A) :** Surface tension and spring constant have the same dimensions.
Reason(R) : Both are equivalent to force per unit length

16. **Assertion(A) :** Method of dimensions cannot be used for deriving formulae containing trigonometrical ratios.
Reason(R) : Trigonometrical ratios have no dimensions.

Statement Type Questions

Options :

1. Statement-1 is true and statement-2 is true
2. Statement-1 is true and statement-2 is false
3. Statement-1 is false and statement-2 is true
4. Statement-1 is false and statement-2 is false

17. **Statement-1:** Plane angle is a dimensionless quantity.
Statement-2: All supplementary quantities are dimensionless.

18. **Statement-1 :**The size (u) of the unit of physical quantity and its numerical magnitude (n) are related to each other by the relation
nu = constant
Statement-2: The choice of mass, length and time as fundamental quantities is not unique.

19. **Statement-1:** The MKS system is a coherent system of units
Statement-2: In SI, joule is the unit for all forms of energy

20. **Statement-1:** Two quantities which are to be added must have the same dimensions
Statement-2: Two quantities which are to be multiplied may have the same dimensions.

21. **Statement-1:**Susceptibility is expressed as Am^{-1}.
Statement-2: Magnetic flux is expressed as JA^{-1}

22. **Statement-1 :**Electromotive force is expressed in newton.
Statement-2: Electric intensity is expressed in NC^{-1}

23. **Statement-1**:The quantity $\dfrac{e^2}{\epsilon_0 ch}$ is dimensionless
Statement 2: $\dfrac{1}{\sqrt{\mu_0 \epsilon_0}}$ has the dimensions of velocity and is numerically equal of velocity of light.

24. **Statement-1 :** Electric current is a scalar
Statement-2 : All fundamental physical quantities are scalars

25. **Statement-1 :** Pressure can be subtracted from pressure gradient
Statement-2: Only like quantities can be added or subtracted from each other

26. **Statement-1 :** Energy cannot be divided by volume
Statement-2 : Dimensions of energy and volume are different

27. **Statement-1:** Light year is a unit of time
Statement-2: Light year is the distance traveled by light in vacuum in one year.

28. **Statement-I:** Dimensional analysis can give us the numerical value of proportionality constants that may appear in an algebraic expression.
Statement-II: Dimensional analysis make use of the fact that dimensions can be treated as algebraic quantities.

29. **Statement-I:** The product of the numerical value and unit of physical quantity remains same in every system of unit.
Statement-II: magnitude of a physical quantity remains same in every system of units.

30. **Statement-I:** Systematic errors can be removed completely.
Statement-II: the cause of systematic errors can be known.

31. **Statement-I:** Random errors can be positive or negative.
Statement-II: Cause of random errors are uncertain.

32. **Statement-I:**In the measurement of g using simple pendulum generally we take central position (mean position) of the oscillation as reference position for measuring time of oscillation.
Statement-II: This reduces the human error in measurement of time.

33. **Statement-I:** When a length of 2.0 m is converted into centimeter, the result is 200cm
Statement-II: The numerical value of a measurement is proportional to reciprocal of the size of unit used.

34. **Statement-I:**The length of an object is measured with two instruments as l_1=4.01cm and l_2=4.009cm.The second instrument has a better resolution.
Statement-II: More value is the least count of an instrument , better is the resolution.

35. **Statement-I:**If a physical quantity has a unit , it must not be dimensionless.
Statement-II: No physical quantity exists which has dimension but no unit.

36. **Statement-I:** A formula derived using dimensional analysis obeys principle of homogenity .
Statement-II: A physically correct relation is always in accordance with principle of homogenity

37. **Statement-I:** Mass, length and time are fundamental quantities.
Statement-II: Mass,length and time are independent of on another.

38. **Statement-I:** The number of significant figures in 0.001 is 1 while in 0.100 it is 3.
Statement-II: Zeros before a non-zero significant digit are not counted while zeros after a non-zero significant digit are counted.

39. **Statement-I:** If error in measurement of mass is 2% and that in measurement of velocity is 5% than error in measurement of kinetic energy is 6%.
Statement-II: Error in kinetic energy is $\frac{\Delta K}{K}=\left(\frac{\Delta m}{m}+2\frac{\Delta v}{v}\right)$.

More than One Answer Questions

40. A book with many printing errors contains four different expressions for the displacement 'y' of a particle executing simple harmonic motion. The wrong formula on dimensional basis (v=velocity)

i. $y=A\sin\left(2\pi t/T\right)$ **ii.** $y=A\sin\left(Vt\right)$

iii. $y=A/T\sin\left(t/A\right)$ **iv.** $y=\frac{A}{\sqrt{2}}\left(\sin\omega t+\cos\omega t\right)$

1)ii only 2)ii and iii only 3)iii only 4)iii and iv only

41. Three of the quantities defined below have the same dimensional formula. Identify them.

i) $\sqrt{Energy/mass}$ **ii)** $\sqrt{pressure/density}$

iii) $\sqrt{Force/linear\ density}$

iv) $\sqrt{Angular\ frequency/radius}$

1) i,ii,iii 2) ii,iii,iv 3) iii,iv,i 4) iv,i,ii

42. Which of the following is not a unit of time?
a) parsec b)light year c) micron d) sec
1) a and c 2) a and b 3) a,b and c 4) all

43. Which of the following is dimensionless?
a)Boltzmann's constant b)Planck's constant
c) Poisson's ratio d) Relative density
1) a and b 2) c and b 3) c and d 4) d and a

44. Which of the following pairs have same dimensions.
a) Torque and work
b) Angular momentum and work
c) Energy and Young's modulus
d) Light year and wavelength
1) a and b 2) b and c 3) c and d 4) a and d

45. The pair of physical quantities that have the same dimensions are
a) Reynold's number and coefficient of friction
b) Latent heat and gravitational potential
c)angular velocity and frequency of light wave
d) Planck's constant and torque
1) b and c are correct 2) a and b are correct
3) a,b and c are correct 4) all are correct

46. Choose the false statement from given statements.
I.Relative permittivity is dimensionless variable
II. Angular displacement has neither units nor dimensions
III.Refractive index is dimensionless variable
IV. Permeability of vacuum is dimensional constant
1)only I and II 2)Only II 3)Only III 4)Only IV

47. The SI unit of inductance, henry can be written as
a) weber/ampere b) volt second/ampere
c) joule/(ampere)$^{-2}$ d) ohm/second
1) a & c are correct 2) a & d are correct
3)a, b, & c are correct 4) a & b are correct

Ascending & Descending Order

48. Arrange the following lengths in increasing order
I. 1 angstrom II. 1 Micron
III. 1 fermi IV. 1 light year
1. III, I, II, IV 2. I, II, III, IV
3. III, II, I, IV 4. II, III, I, IV

49. Arrange the following multiples in decreasing order
I. milli II. centi III. nano IV. pico
1. IV, II, I, III 2. II, I, III,IV
3. I, III, II, IV 4. II,I,IV,III

50. Arrange the following physical quantities in increasing order of their magnitudes
I. 10^6 **dyne** **II. 1 N**
III. 3 kg ms^{-2} **IV.** $10^7\,gm\ cm\ s^{-2}$

1.	II	I	III	IV
2.	IV	I	III	II
3.	II	III	I	IV
4.	I	II	III	IV

51. Arrange the following physical quantities in the decreasing order of dimension of length
I. Density II. Pressure
III. Power IV. Impulse
1. I, II, III, IV 2. III, II, I, IV
3. IV, I,II, III 4. III, IV, II, I

52. The correct order in which the dimensions of length increases in the following physical quantities is
a) permittivity b) resistance
c) magnetic permeability d) stress
1) a, b, c, d 2) d, c, b, a
3) a, d, c, b 4) c, b, d, a

53. The correct order in which the dimensions of "length " decreases in the following physical quantities is
a) Coefficient of viscosity
b) Thermal capacity c) Escape velocity
d) Density
1) b,c,a,d 2) a,b, c,d 3) c,d,b,a 4) a,d,c,b

54. The correct order in which the dimensions of "time" increases in the following physical quantities is
a) Stress b) Period of revolution of satellite
c) Angular displacement
d) Coefficient of thermal conductivity

1)	a	b	c	d
2)	d	c	b	a
3)	a	d	c	b
4)	d	a	c	b

LEVEL-IV- KEY

Matching Questions

1) a-s, b-p,r, c-q, d-r,s
2) a-r, b-p, c-s, d-q
3) a-p, b-q, c-s, d-t
4) a-III, b-II, c-IV d-I
5) a-g b-h c-e d-f
6) a-g b-h c-e d-f
7) a-g b-j c-e d-f
8) a-III b-I c-IV d-II

Assertion & Reason Type

9)1 10)2 11)2 12)1 13)3 14)1
15)1 16)1

Statement Type

17)1 18)3 19)1 20)1 21)3 22)3
23)1 24)1 25)3 26)3 27)3 28)3
29)1 30)1 31)1 32)1 33)1 34)2
35)3 36)1 37)1 38)1 39)3

More than one answer type questions

40)2 41)1 42)3 43)3 44)4 45)1
46)2 47)4

Ascending & Descending Order

48) 1 49)2 50)3 51)4 52)3 53)1
54)4

LEVEL - IV - HINTS

9. from principle of homogenity.
10. Plane angle $=\dfrac{arc\,length}{radius}=M^0L^0T^0$
11. dimensional method is not useful for deriving proportional constants.
12. supplementary quantities have no dimensional formula.

13 & 14 $N_1U_1=N_2U_2$ and $N\propto\dfrac{1}{U}$

15. by dimensional method
16. Method of dimensions can not be used for trignometric ,logarthemic and exponential functions