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# Physics and measurement

**Physical Quantity**

A quantity which can be measured and by which various physical happenings can be explained and expressed in the form of laws is called a physical quantity. For example length, mass, time, force *etc*.

**Fundamental quantities:** Out of large number of physical quantities which exist in nature, there are only few quantities which are independent of all other quantities and do not require the help of any other physical quantity for their definition, therefore these are called absolute quantities. These quantities are also called fundamental or basic quantities, as all other quantities are based upon and can be expressed in terms of these quantities.

**Derived quantities:** All other physical quantities can be derived by suitable multiplication or division of different powers of fundamental quantities. These are therefore called derived quantities.

**System of units:** A complete set of units, both fundamental and derived for all kinds of physical quantities is called system of units. The common systems are given below

**(1) CGS system:** This system is also called Gaussian system of units. In this length, mass and time have been chosen as the fundamental quantities and corresponding fundamental units are centimetre (*cm*), gram (*g*) and second (*s*) respectively.

**(2) MKS system:** This system is also called Giorgi system. In this system also length, mass and time have been taken as fundamental quantities, and the corresponding fundamental units are *metre*, kilogram and second.

**(3) FPS system:** In this system foot, pound and second are used respectively for measurements of length, mass and time. In this system force is a derived quantity with unit poundal.

**(4) S. I. system:** It is known as International system of units, and is extended system of units applied to whole physics. There are seven fundamental quantities in this system. These quantities and their units are given in the following table

## Unit and symbol of quantities

| Quantity | Unit | Symbol |
|---|---|---|
| Length | metre | $m$ |
| Mass | kilogram | $kg$ |
| Time | second | $s$ |
| Electric Current | ampere | $A$ |
| Temperature | Kelvin | $K$ |
| Amount of Substance | mole | $mol$ |
| Luminous Intensity | candela | $cd$ |

Besides the above seven fundamental units two supplementary units are also defined – Radian (*rad*) for plane angle and Steradian (*sr*) for solid angle.

**Standards of Length, Mass and Time**

**(1) Length:** Standard metre is defined in terms of wavelength of light and is called atomic standard of length.

The metre is the distance containing 1650763.73 wavelength in vacuum of the radiation corresponding to orange red light emitted by an atom of krypton-86.

Now a days metre is defined as length of the path travelled by light in vacuum in 1/299,7792, 45 part of a second.

**(2) Mass:** The mass of a cylinder made of platinum-iridium alloy kept at International Bureau of Weights and Measures is defined as 1 *kg*.

On atomic scale, 1 *kilogram* is equivalent to the mass of $5.0188 \times 10^{25}$ atoms of ${}_6C^{12}$ (an isotope of carbon).

**(3) Time:** 1 *second* is defined as the time interval of 9192631770 vibrations of radiation in *Cs*-133 atom. This radiation corresponds to the transition between two hyperfine level of the ground state of *Cs*-133.

**Practical Units**

**(1) Length**

**(i)** 1 fermi = 1 $fm = 10^{-15}\ m$

**(ii)** 1 $X$-ray unit = $1XU = 10^{-13}\ m$

**(iii)** 1 angstrom = $1Å = 10^{-10}\ m = 10^{-8}\ cm = 10^{-7}\ mm = 0.1\ \mu mm$

**(iv)** 1 micron = $\mu m = 10^{-6}\ m$

**(v)** 1 astronomical unit = 1 $A.U.$ = $1.49 \times 10^{11}\ m \approx 1.5 \times 10^{11}\ m \approx 10^{8}\ km$

**(vi)** 1 Light year = 1 $ly$ = $9.46 \times 10^{15}\ m$

**(vii)** 1 *Parsec* = 1*pc* = 3.26 light year

**(2) Mass**

**(i)** Chandra Shekhar unit : 1 $CSU$ = 1.4 times the mass of sun = $2.8 \times 10^{30}\ kg$

**(ii)** Metric tonne : 1 Metric tonne = 1000 $kg$

**(iii)** Quintal : 1 Quintal = 100 $kg$

**(iv)** Atomic mass unit (*amu*) : $amu = 1.67 \times 10^{-27}\ kg$

Mass of proton or neutron is of the order of 1 *amu*

**(3) Time**

**(i)** Year: It is the time taken by the Earth to complete 1 revolution around the Sun in its orbit.

**(ii)** Lunar month: It is the time taken by the Moon to complete 1 revolution around the Earth in its orbit. 1 $L.M.$ = 27.3 days

**(iii)** Solar day: It is the time taken by Earth to complete one rotation about its axis with respect to Sun. Since this time varies from day to day, average solar day is calculated by taking average of the duration of all the days in a year and this is called Average Solar day. 1 Solar year = 365.25 average solar day or average solar day $= \frac{1}{365.25}$ the part of solar year

**(iv)** Sedrial day: It is the time taken by earth to complete one rotation about its axis with respect to a distant star. 1 Solar year = 366.25 Sedrial day = 365.25 average solar day. Thus 1 Sedrial day is less than 1 solar day.

***(v)*** Shake: It is an obsolete and practical unit of time. 1 Shake = $10^{-8}$ *sec*

**Dimensions**

When a derived quantity is expressed in terms of fundamental quantities, it is written as a product of different powers of the fundamental quantities. The powers to which fundamental quantities must be raised in order to express the given physical quantity are called its dimensions.

## Application of Dimensional Analysis

**(1)** To find the unit of a physical quantity in a given system of units: *e.g.*, Work = Force × Displacement. So $[W] = [MLT^{-2}] \times [L] = [ML^2T^{-2}]$

So its unit in C.G.S. system will be $g\ cm^2/s^2$ which is called *erg* while in M.K.S. system will be $kg\text{-}m^2/s^2$ which is called *joule*.

**(2)** To find dimensions of physical constant or coefficients:

**(i)** Gravitational constant: According to Newton's law of gravitation $F = G\frac{m_1m_2}{r^2}$ or $G = \frac{Fr^2}{m_1m_2}$

Substituting the dimensions of all physical quantities $[G] = \frac{[MLT^{-2}][L^2]}{[M][M]} = [M^{-1}L^3T^{-2}]$

**(ii)** Plank constant: According to Planck $E = h\nu$ or $h = \frac{E}{\nu}$, Substituting the dimensions of all physical quantities $[h] = \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$

**(iii)** Coefficient of viscosity: According to Poiseuille's formula $\frac{dV}{dt} = \frac{\pi pr^4}{8\eta l}$ or $\eta = \frac{\pi pr^4}{8l(dV/dt)}$

Substituting the dimensions of all physical quantities $[\eta] = \frac{[ML^{-1}T^{-2}][L^4]}{[L][L^3/T]} = [ML^{-1}T^{-1}]$

**(3) To convert a physical quantity from one system to the other:** The measure of a physical quantity is nu = constant

If a physical quantity $X$ has dimensional formula $[M^aL^bT^c]$ and if (derived) units of that physical quantity in two systems are $[M_1^aL_1^bT_1^c]$ and $[M_2^aL_2^bT_2^c]$ respectively and $n_1$ and $n_2$ be the numerical values in the two systems respectively, then $n_1[u_1] = n_2[u_2] \Rightarrow$ $n_1[M_1^aL_1^bT_1^c] = n_2[M_2^aL_2^bT_2^c] \Rightarrow n_2 = n_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c$

**(4) To check the dimensional correctness of a given physical relation:** This is based on the '*principle of homogeneity*'. According to this principle the dimensions of each term on both sides of an equation must be the same.

If $X = A \pm (BC)^2 \pm \sqrt{DEF}$, then according to principle of homogeneity $[X] = [A] = [(BC)^2]$ $= [\sqrt{DEF}]$

If the dimensions of each term on both sides are same, the equation is dimensionally correct, otherwise not. A dimensionally correct equation may or may not be physically correct.

***Example*: (i)** $F = mv^2/r^2$

By substituting dimension of the physical quantities in the above relation, $[MLT^{-2}] = [M][LT^{-1}]^2/[L]^2$

*i.e.* $[MLT^{-2}] = [MT^{-2}]$

As in the above equation dimensions of both sides are not same; this formula is not correct dimensionally, so can never be physically.

***Example*: (ii)** $s = ut - (1/2)at^2$

By substituting dimension of the physical quantities in the above relation

$[L] = [LT^{-1}][T] - [LT^{-2}][T^2]$

*i.e.* $[L] = [L] - [L]$

As in the above equation dimensions of each term on both sides are same, so this equation is dimensionally correct. However, from equations of motion we know that $s = ut + (1/2)at^2$

**(5) As a research tool to derive new relations:** If one knows the dependency of a physical quantity on other quantities and if the dependency is of the product type, then using the method of dimensional analysis, relation between the quantities can be derived.

***Example* : (i) Time period of a simple pendulum.**

Let time period of a simple pendulum is a function of mass of the bob ($m$), effective length ($l$), acceleration due to gravity ($g$) then assuming the function to be product of power function of $m$, $l$ and $g$

*i.e.*, $T = Km^x l^y g^z$ ; where $K$ = dimensionless constant

If the above relation is dimensionally correct then by substituting the dimensions of quantities –

$[T] = [M]^x [L]^y [LT^{-2}]^z$ or $[M^0L^0T^1] = [M^xL^{y+z}T^{-2z}]$

Equating the exponents of similar quantities $x = 0$, $y = 1/2$ and $z = -1/2$

So the required physical relation becomes $T = K\sqrt{\frac{l}{g}}$

The value of dimensionless constant is found ($2\pi$) through experiments so $T = 2\pi\sqrt{\frac{l}{g}}$

**Limitations of Dimensional Analysis**

Although dimensional analysis is very useful it cannot lead us too far as,

**(1)** If dimensions are given, physical quantity may not be unique as many physical quantities have same dimensions. For example if the dimensional formula of a physical quantity is $[ML^2T^{-2}]$ it may be work or energy or torque.

**(2)** Numerical constant having no dimensions [*K*] such as (1/2), 1 or $2\pi$ *etc*. cannot be deduced by the methods of dimensions.

**(3)** The method of dimensions cannot be used to derive relations other than product of power functions. For example, $s = ut + (1/2)at^2$ or $y = a\sin\omega t$

Cannot be derived by using this theory (try if you can). However, the dimensional correctness of these can be checked.

**(4)** The method of dimensions cannot be applied to derive formula if in mechanics a physical quantity depends on more than 3 physical quantities as then there will be less number (= 3) of equations than the unknowns (>3). However still we can check correctness of the given equation dimensionally. For example $T = 2\pi\sqrt{I/mgl}$ cannot be derived by theory of dimensions but its dimensional correctness can be checked.

**(5)** Even if a physical quantity depends on 3 physical quantities, out of which two have same dimensions, the formula cannot be derived by theory of dimensions, *e.g.*, formula for the frequency of a tuning fork $f = (d/L^2)v$ cannot be derived by theory of dimensions but can be checked.

**Significant Figures**

Significant figures in the measured value of a physical quantity tell the number of digits in which we have confidence. Larger the number of significant figures obtained in a measurement, greater is the accuracy of the measurement. The reverse is also true.

The following rules are observed in counting the number of significant figures in a given measured quantity.

**(1) All non-zero digits are significant.**

***Example:*** 42.3 has three significant figures.

243.4 has four significant figures.

24.123 has five significant figures.

**(2)** A zero becomes significant figure if it appears between two non-zero digits.

***Example:*** 5.03 has three significant figures.

5.604 has four significant figures.

4.004 has four significant figures.

**(3)** Leading zeros or the zeros placed to the left of the number are never significant.

***Example:*** 0.543 has three significant figures.

0.045 has two significant figures.

0.006 has one significant figure.

**(4)** Trailing zeros or the zeros placed to the right of the number are significant.

***Example:*** 4.330 has four significant figures.

433.00 has five significant figures.

343.000 has six significant figures.

**(5)** In exponential notation, the numerical portion gives the number of significant figures.

***Example:*** $1.32 \times 10^{-2}$ has three significant figures.

$1.32 \times 10^{4}$ has three significant figures.

**Rounding Off**

While rounding off measurements, we use the following rules by convention:

**(1)** If the digit to be dropped is less than 5, then the preceding digit is left unchanged.

**(2)** If digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised by one, if it is odd.

If digit to be dropped is 5 or 5 followed by zeros, then preceding digit is left unchanged, if it is even.

If the digit to be dropped is 5 followed by digits other than zero, then the preceding digit is raised by one.

**(3)** If the digit to be dropped is more than 5, then the preceding digit is raised by one.

**Errors of Measurement**

This difference in the true value and measured value of a quantity is called error of measurement.

**(1) Absolute error:** Absolute error in the measurement of a physical quantity is the magnitude of the difference between the true value and the measured value of the quantity.

Let a physical quantity be measured $n$ times. Let the measured value be $a_1$, $a_2$, $a_3$, ….. $a_n$.

The arithmetic mean of these value is $a_m = \frac{a_1 + a_2 + ...... + a_n}{n}$

Usually, $a_m$ is taken as the true value of the quantity, if the same is unknown otherwise.

By definition, absolute errors in the measured values of the quantity are

$$\Delta a_1 = a_m - a_1$$

$$\Delta a_2 = a_m - a_2$$

…………

$$\Delta a_n = a_m - a_n$$

The absolute errors may be positive in certain cases and negative in certain other cases.

**(2) Mean absolute error:** It is the arithmetic mean of the magnitudes of absolute errors in all the measurements of the quantity. It is represented by $\overline{\Delta a}$. Thus $\overline{\Delta a} = \frac{|\Delta a_1| + |\Delta a_2| + .....|\Delta a_n|}{n}$

Hence the final result of measurement may be written as $a = a_m \pm \overline{\Delta a}$

This implies that any measurement of the quantity is likely to lie between $(a_m + \overline{\Delta a})$ and $(a_m - \overline{\Delta a})$.

**(3) Relative error or Fractional error:** The relative error or fractional error of measurement is defined as the ratio of mean absolute error to the mean value of the quantity measured. Thus

Relative error or Fractional error $= \frac{\text{Mean absolute error}}{\text{Mean value}} = \frac{\overline{\Delta a}}{a_m}$

**(4) Percentage error:** When the relative/fractional error is expressed in percentage, we call it percentage error. Thus Percentage error $= \frac{\overline{\Delta a}}{a_m} \times 100\%$

**Propagation of Errors**

**(1) Error in sum of the quantities:** Suppose $x = a + b$

Let $\Delta a$ = absolute error in measurement of $a$

$\Delta b$ = absolute error in measurement of $b$

$\Delta x$ = absolute error in calculation of $x$

*i.e.* sum of $a$ and $b$.

The maximum absolute error in $x$ is $\Delta x = \pm(\Delta a + \Delta b)$

Percentage error in the value of $x = \frac{(\Delta a + \Delta b)}{a + b} \times 100\%$

**(2) Error in difference of the quantities:** Suppose $x = a - b$

Let $\Delta a$ = absolute error in measurement of $a$,

$\Delta b$ = absolute error in measurement of $b$

$\Delta x$ = absolute error in calculation of $x$ *i.e.* difference of $a$ and $b$.

The maximum absolute error in $x$ is $\Delta x = \pm(\Delta a + \Delta b)$

Percentage error in the value of $x = \frac{(\Delta a + \Delta b)}{a - b} \times 100\,\%$

**(3) Error in product of quantities:**

Suppose $x = a \times b$

Let $\Delta a$ = absolute error in measurement of $a$,

$\Delta b$ = absolute error in measurement of $b$

$\Delta x$ = absolute error in calculation of $x$ *i.e.* product of $a$ & $b$.

The maximum fractional error in $x$ is $\frac{\Delta x}{x} = \pm\left(\frac{\Delta a}{a} + \frac{\Delta b}{b}\right)$

Percentage error in the value of $x$

= (% error in value of $a$) + (% error in value of $b$)

**(4) Error in division of quantities:** Suppose $x = \frac{a}{b}$

Let $\Delta a$ = absolute error in measurement of $a$,

$\Delta b$ = absolute error in measurement of $b$

$\Delta x$ = absolute error in calculation of $x$ *i.e.* division of $a$ and $b$.

The maximum fractional error in $x$ is $\frac{\Delta x}{x} = \pm\left(\frac{\Delta a}{a} + \frac{\Delta b}{b}\right)$

Percentage error in the value of $x$ = (% error in value of $a$) + (% error in value of $b$)

**(5) Error in quantity raised to some power:** Suppose $x = \frac{a^n}{b^m}$

Let $\Delta a$ = absolute error in measurement of $a$,

$\Delta b$ = absolute error in measurement of $b$

$\Delta x$ = absolute error in calculation of $x$

The maximum fractional error in $x$ is $\frac{\Delta x}{x} = \pm\left(n\frac{\Delta a}{a} + m\frac{\Delta b}{b}\right)$

Percentage error in the value of $x$

= $n$ (% error in value of $a$) + $m$ (%error in value of $b$)

**Vernier callipers:**

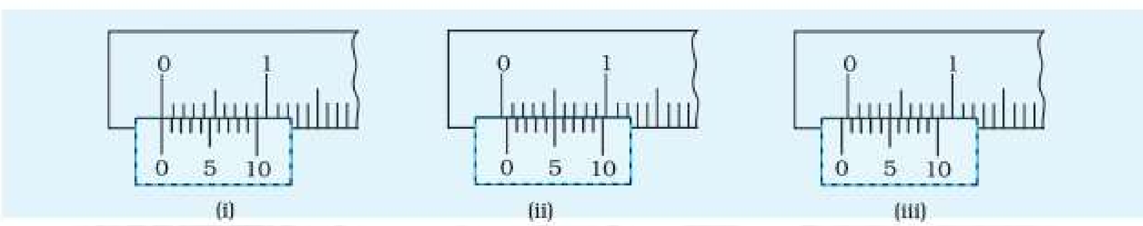
The difference in the magnitude of one main scale division (M.S.D.) and one vernier scale division (V.S.D.) is called the least count of the instrument, as it is the smallest distance that can be measured using the instrument.

n V.S.D. = (n – 1) M.S.D.

Formulas Used

**(a)** Least count of vernier callipers = the magnitude of the smallest division on the main scale/ the total number of small divisions on the vernier scale

**(b)** Zero error and its correction When the jaws A and B touch each other, the zero of the Vernier should coincide with the zero of the main scale. If it is not so, the instrument is said to possess zero error (e). Zero error may be positive or negative, depending upon whether the zero of vernier scale lies to the right or to the left of the zero of the main scale. This is shown by the Fig. E1.2 (ii) and (iii). In this situation, a correction is required to the observed readings.



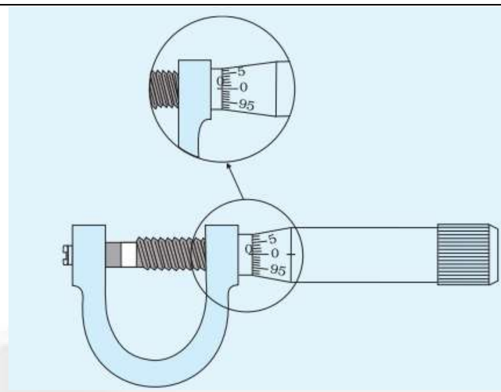

Zero error (i) no zero error (ii) positive zero error (iii) negative zero error.

∴ True Reading = Observed Reading – (– Zero error)

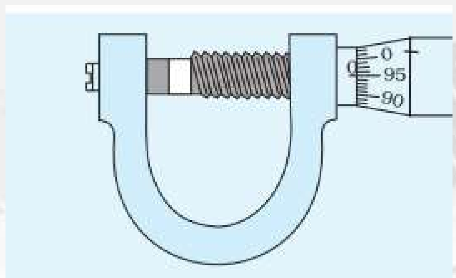
**Screw guage:**

The distance advanced by the screw when it makes its one complete rotation is the separation between two consecutive threads. This distance is called the Pitch of the screw

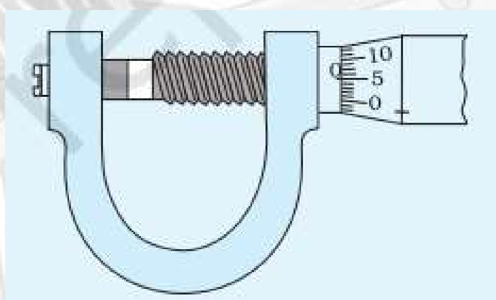
**Zero Error:** When the end of the screw and the surface of the stud are in contact with each other, the linear scale and the circular scale reading should be zero. In case this is not so, the screw gauge is said to have an error called zero error.




A screw gauge with no zero error




Showing a positive zero error




Showing a negative zero error

# Exercise-1

**Physical quantities and units**

**1.** If E and H represents the intensity of electric field and magnetizing field respectively, then the unit of E/H will be :

(1)ohm (2) mho (3) joule (4) newton

**2.** Electric field in a cerain region is given by $E = \left( \frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j} \right)$. The SI unit of A and B are:

(1) $Nm^3C^{-1}; Nm^2C^{-1}$ (2) $Nm^2C^{-1}; Nm^3C^{-1}$

(3) $Nm^2C; Nm^2C$ (4) $Nm^2C; Nm^3C$

## Measurement

**3.** V.calliper is invented by

(1) Pierre Query (2) George Vernier (3) Piere Vernier (4) None

**4.** Least Count of an instrument is

(1) Min. distance between two marks on the scale

(2) Minimum value which can measured by instrument

(3)Minimum value which can accurately measure by instrument

(4) None

**5.** What is the value of least count of commonly available V. callipers

(1) 0.1 cm (2) 0.01 cm (3) 0.001 cm (4) 0.0001 cm

**6.** Zero error is positive of Vernier when

(1) Zero mark of Vernier coincides with zero of main scale

(2) Zero mark of Vernier lies towards left of zero of main scale

(3)Zero mark of Vernier lies towards right of zero main scale.

(4) None

**7.** For a more accurate vernier callipers :

(1) L.C. should be more

(2) L.C. should be less

(3) Accuracy does not depend on L.Count

(4) none

**8.** The measured value is

(1) Main scale reading + V.scale reading

(2) M.S.reading × L.C. + V.S. reading

(3) (M.S. reading + V.S. reading) × L.C.

(4) M.S. reading + V.S. reading L.C.

**9.** The measured value in case of zero error.
(1) Main scale reading + (circular scale reading) × L.C. – (+ ve zero error)
(2) Main scale reading + (C.S.R.) × L.C. + (–ve zero error)
(3) M.S.R. + (C.S.R.) × L.C. + (–ve zero error)
(4) (M.S.R.) L.C. + C.S.R. – (+ ve zero error)

**10.** Pitch of a screw gauge-
(1)Axial advacement of M.S. in one rotation of circular scale
(2)Transverse movement of M.S. in one rotation of C.S.
(3)Axial advancement of circular scale when M.S. rotated by one rotation
(4) None

**11.** The metal of screw of screw gauge is
(1) Tungeston (2) Lead (3) Gun Metal (4) Iron

**12.** The +ve zero error is
(1) When zero watch with base line (2) when zero is above the base line
(3) when zero is below the base line (4) None

**13.** The –ve zero error is
(1) When zero watch with base line (2) when zero is above the base line
(3) when zero is below the base line (4) None

**14.** Micrometer is the name of
(1) Vernier calipers (2) Screw gauge
(3) Spherometer (4) None

**15.** The least count of the main scale of a Vernier callipers is 1mm. Its Vernier scale is divided into 10 divisions and coincide with 9 divisions of the main scale. When jaws are touching each other, the 7th division of Vernier scale coincides with a division of main scale and the zero of Vernier scale is lying right side of the zero of main scale. When this Vernier is used to measure length of a cylinder the zero of the vernier scale between 3.1cm and 3.2cm and 4th VSD coincides with a main scale division. The length of the cylinder is (VSD is Vernier scale division)
(1) 3.21 cm (2) 2.99cm (3) 3.07cm (4) 3.2 cm

**16.** Using screw gauge of pitch 0.1 cm and 50 divisions on its circular scale, the thickness of an object is measured .it should correctly be recorded as
(1) 2.124cm (2) 2.123 cm (3) 2.125cm (4) 2.121cm

**17.** A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5mm is noticed on the pitch scale. The nature of zero error involved ,and the least count of the screw gauge, are respectively
(1) Positive, 0.1mm(2) Positive 10 $\mu m$ (3) Negative, 2 $\mu m$ (4) Positive, 0.1 $\mu m$

**18.** If the screw on a screw –gauge is given six rotations, it moved by 3mm on the main scale. If there are 50 divisions on the circular scale the least count of the screw gauge is :

(1) 0.002cm (2) 0.001cm (3) 0.01cm (4) 0.02cm

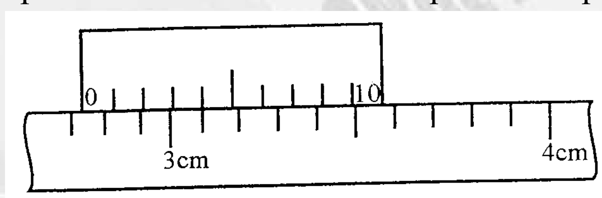
**19.** While measuring the length of the rod by Vernier calipers the reading on main scale is 6.4cm and the eighth division on Vernier in line with marking on main scale division. If the least count of calipers is 0.01cm and zero error is $-0.04$ cm, find the length of the rod will be

A) 6.82 cm B) 6.52 cm C) 6.42 cm D) 6.86 cm

**20.** The circular head of a screw gauge is divided into 200 divisions and move 1mm ahead in one revolution. If the same instrument has a zero error of $-0.05$ mm and the reading on the main scale in measuring diameter of wire is 6mm and that on circular scale is 45 then the diameter of the wire will be

A) 5.875 mm B) 6.200 mm C) 6.275 mm D) 6.475 mm

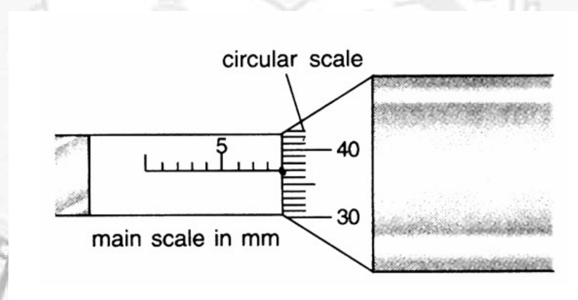
**21.** The diagram shows part of the vernier scale on a pair of calipers.




Which reading is correct?

A) 2.74 cm B) 3.10cm C) 3.26cm D) 3.64cm

**22.** Study the figures carefully, what will be the diameter of wire?
(LC of screw gauge = 0.01mm and main scale division is 1mm)




A) 0.837 cm B) 0.567 cm C) 0.783 cm D) 0.873 cm

**23.** In a vernier calipers n divisions of its main scale match with (n+1) divisions on its vernier scale . Each divisions of the main scale is a units. Using the vernier principle . Calculate its least count [JEE 2004]

(1) $\frac{a}{n+1}$ (2) $\frac{a}{n-1}$ (3) $\frac{2a}{n+1}$ (4) $\frac{a}{2n+1}$

**24.** A wire has mass $0.3 \pm 0.003g$ . Radius $0.5 \pm 0.005mm$ and length $6 \pm 0.06cm$. The maximum percentage error in the measurement of its density is [JEE 2004]

(1) 1 (2) 2 (3) 3 (4) 4

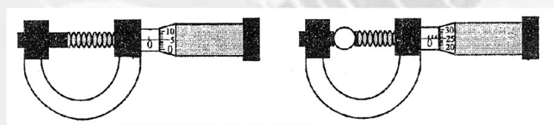
**25.** In a Searle's experiment, the diameter of the wire as measured by a screw gauge of least count 0.001 cm is 0.050 cm. The length, measured by a scale of least count 0.1 cm, is 110.0 cm. When a weight of exactly 50 N is suspended from the wire, the extension is measured to be 0.125 cm by a micrometer 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. [JEE 2004]

(1) 4.89% (2) 1.26% (3) 9.67% (4) 15.56%

**26.** In a resonance column method, resonance occurs at two successive level of l1 $l_1$ = 30.7 cm and $l_2$ = 63.2 cm using a tuning fork of f = 512 Hz(exact). What is the maximum error in measuring speed of sound using relations $V = f\lambda \quad \lambda = 2(l_2 - l_1)$ [JEE 2005]

(1) 256 cm/sec (2) 92 cm/sec (3) 128 cm/sec (4) 204.8 cm/sec

**27.** The circular divisions of shown screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball is [JEE 2006]



(1) 2.25 mm (2) 2.20 mm (3) 1.20 mm (4) 1.25 mm

**28.** A student performs an experiment for determination of $g\left(=\frac{4\pi^2 l}{T^2}\right) l = 1m$ and he commits an error of 0.lsec . For the experiment takes the time of n oscillations with the stop watch of least count $\Delta T$ and he commits a human error of 0.1 sec. For which of the following data, the measurement of g will be most accurate? $\Delta l \quad \Delta T n$ Amplitude of oscillation [JEE 2006]

(1)5 mm 0.2 sec 10 5 mm (2) 5 mm 0.2 sec 20 5 mm
(3) 5 mm 0.1 sec 20 1 mm (4) 1 mm 0.1 sec 50 1 mm

**29.** In an experiment of determine the focal length (f) a concave mirror by the u-v method, a student places the object pin Aon the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then, [JEE 2007]

(1) x < f (2) f < x < 2f (3) x = 2f (4) x > 2f

**30.** A student performs an experiment to determine the Young's modulus of a wire, exactly 2 m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ± 0.05 mm at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take g = 9.8 m/s2 (exact). The Young's modulus obtained from the reading is [JEE 2007]

(1) $(2.0 \pm 0.3) \times 10^{11}\ N/m^2$ (2) $(2.0 \pm 0.2) \times 10^{11}\ N/m^2$ .

(3) $(2.0 \pm 0.1) \times 10^{11}\ N/m^2$ (4) $(2.0 \pm 0.05) \times 10^{11}\ N/m^2$

**31.** In the formula X = $3YZ^2$ X and Z have dimensions of capacitance and magnetic induction respectively. What are the dimensions of Y in MKSQ system ? [JEE-1995,2/100]

(1) $\left[M^{-3}L^{-1}T^{3}Q^{4}\right]$ (2) $\left[M^{-3}L^{-2}T^{4}Q^{4}\right]$

(3) $\left[M^{-2}L^{-2}T^{4}Q^{4}\right]$ (4) $\left[M^{B}L^{-2}T^{4}Q^{1}\right]$

**32.** The dimensions of $\left(\frac{1}{2}\right)\ \varepsilon_0 E^2$ ($\varepsilon_0$ : permittivity of free space , E: electric field ) is :

(1) $MLT^{-1}$ (2) $ML^2T^{-2}$ (3) $ML^{-1}T^{-2}$ (4) $ML^2T^{-1}$

**33.** A quantity X is given by $\varepsilon_0 L \frac{\Delta V}{\Delta t}$ . Where $\varepsilon_0$ is the permittivity of free space, L is length, $\Delta$ V is potential difference and $\Delta t$ is time interval. The dimensional formula for X is the same as that of [JEE Sc.2000'3/105]

**34.** Pressure depends on distance as, $P = \frac{\alpha}{\beta}\exp\left(-\frac{\alpha z}{k\beta}\right)$, where $\alpha$ , $\beta$and k are constants, z is distance, k is Boltzmann's constant and $\theta$ is temperature. The dimension of $\beta$ are[JEE-2004s '3/84]

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

**35.** Which of the following set have different dimensions? [JEE-2005s; 3/60]

(1) Pressure, Young's modulus, Stress
(2) Emf, Potential difference, Electric potential
(3) Heat, Work done, Energy
(4) Dipole moment, Electric flux, Electric field

**36.** Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons $N = 4 \times 10^{27}\ m^{-3}$ Take $\varepsilon_0 = 10^{-11}$ And $m = 10^{-30}$ Where these quantities are in proper SI units [JEE-2011]

(1) 800 nm (2) 600 nm (3) 300 nm (4) 200 nm

# Accuracy; precision of instruments and errors in measurements

**37.** A physical quantity z depends on four observables a,b,c and d, as $z = \frac{a^2 b^{\frac{2}{3}}}{\sqrt{cd^3}}$ The percentage of error in the measurement of a,b,c and d are 2% , 1.5 % , 4% and 2.5% respectively. The percentage of error in z is

(1) 13.5% (2) 14.5% (3) 16.5% (4) 12.25%

**38.** The density of a solid metal sphere is determined by measuring its mass and its diameter. The maximum error in the density of the sphere is $\left(\frac{x}{100}\right)\%$ . If the relative errors in measuring the mass and the diameter are 6.0% and 1.5% respectively the value of x is

(1) 105 (2) 1050 (3) 10.5 (4) 1.03

**39.** A student measuring the diameter of a pencil of circular cross-section with the help of a Vernier scale records the following four readings 5.50mm, 5.55mm, 5.45mm; 5.65 mm. The average of these four readings is 5.5375mm and the standard deviation of the data is 0.07395mm. The average diameter of the pencil should therefore be recorded as

(1) $(5.5375 \pm 0.0739)$ mm (2) $(5.54 \pm 0.07)$mm

(3) $(5.538 \pm 0.074)$ mm (4) $(5.5375 \pm 0.0740)$mm.

**40.** Length of a simple pendulum is 25.0 cm and time of 40 oscillation is 50 sec. If resolution of stop watch is 1 sec then accuracy is g is (in %)

(1) 2.4 (2) 3.4 (3) 4.4 (4) 5.4

**41.** For the four sets of three measured physical quantities as given below. Which of the following options is correct?

(i) $A_1 = 24.36, B_1 = 0.0724, C_1 = 256.2$

(ii) $A_2 = 24.44, B_2 = 16.082 \;\; C_3 = 240.2$

(iii) $A_3 = 25.2, \;\; B_3 = 19.2812, \; C_3 = 236.183$

(iv) $A_4 = 25, \;\; B_4 = 236.191, \; C_4 = 19.5$

(1) $A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2 < A_4 + B_4 + C_4$

(2) $A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3 = A_4 + B_4 + C_4$

(3) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3$

(4) $A_4 + B_4 + C_4 < A_2 + B_2 + C_2 < A_1 + B_1 + C_1 = A_3 + B_3 + C_3$

**42.** Time period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of 'L' is 20.0cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 sec using a wrist watch of 1 sec resolution. What is the percentage error in the determination of 'g'?

(1) 1 (2) 2 (3) 3 (4) 4

**43.** The number of significant digits in the measurement $0.0042$ cm is

A) 2 B) 3 C) 4 D) 5

**Dimensions of physical quantities**

**44.** If velocity [V} , time [T] and force [F] are chosen as the base quantities, the dimensions of the mass will be :

(1) $\left[FT^{-1}V^{-1}\right]$ (2) $\left[FTV^{-1}\right]$ (3) $\left[FT^{2}V\right]$ (4) $\left[FVT^{-1}\right]$

**45.** Which of the following equations is dimensionally incorrect?

Where t=time, h= height, s=surface tension, $\theta$= angle, $\rho$=density, r=radius, g= acceleration due to gravity, v= volume, p= pressure, W=work done, $\Gamma$= torque, $\in$= permittivity, E= electric field, J = current density, L= length

(1) $V = \frac{\pi p a^4}{8nL}$ (2) $h = \frac{2\cos\theta}{\rho r g}$ (3) $J = \in \frac{\partial E}{\partial t}$ (4) W= $\Gamma\theta$

**46.** If force (F), length (I) and time (T) are taken as the fundamental quantities. Then what will be the dimension of density:

(1) $\left[FL^{-4}T^{2}\right]$ (2) $\left[FL^{-3}T^{2}\right]$ (3) $\left[FL^{-5}T^{2}\right]$ (4) $\left[FL^{-3}T^{3}\right]$

**47.** Which of the following is not a dimensionless quantity?

(1) Relative magnetic permeability $(\mu_r)$

(2) Power factor

(3) Permeability of free space $(\mu_0)$

(4) Quality factor

**48.** If ,L,Man dGde note the quantities as energy, angular momentum, mass and respectively, then the dimensions of P in the formula P= $EL^2M^{-5}G^{-2}$ are

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

**49.** Identify the pair of physical quantities which have different dimensions :

(1) Wave number and Rydberg's constant

(2) Stress and Coefficient of elasticity

(3) Coercivity and Magnetisation

(4) Specific heat capacity and Latent heat

**50.** Identify the pair of physical quantities that have same dimensions:
(1) Velocity gradient and decay constant
(2) wien's constant and Stefan constant
(3) Angular frequency and angular momentum
(4) Wave number and Avogadro number

**51.** An expression for a dimensionless quantity P is given by $P=\frac{\alpha}{\beta}\log_e\left(\frac{kt}{\beta x}\right)$;
Where $\alpha\, and\, \beta$ are constants, x is distance; k is Boltzmann constant and t is the temperature. Then the dimensions of $\alpha$ will be:
(1) $\left[M^0L^{-1}T^0\right]$ (2) $\left[ML^0T^{-2}\right]$ (3) $\left[MLT^{-2}\right]$ (4) $\left[ML^2T^{-2}\right]$

**52.** The dimension of mutual inductance is :
(1) $\left[ML^2T^{-2}A^{-1}\right]$ (2) $\left[ML^2T^{-3}A^{-1}\right]$ (3) $\left[ML^2T^{-2}A^{-2}\right]$ (4) $\left[ML^2T^{-3}A^{-2}\right]$

**53.** The SI unit of a physical quantity is pascal-second The dimensional formula of this quantity will be
(1) $\left[ML^{-1}T^{-1}\right]$ (2) $\left[ML^{-1}T^{-2}\right]$ (3) $\left[ML^2T^{-1}\right]$ (4) $\left[M^{-1}L^3T^0\right]$

**54.** If L, C and R are the self-inductance capacitance and resistance respectively, which of the following does not have the dimension of time?
(1) RC (2) $\frac{L}{R}$ (3) $\sqrt{LC}$ (4) $\frac{L}{C}$

**55.** In Vander Waals equation $\left[P+\frac{a}{V^2}\right][V-b]=RT$ ; P is pressure, V is volume, R is universal gas constant and T is temperature. The ratio of constants $\frac{a}{b}$ is dimensionally equal to :
(1) $\frac{P}{V}$ (2) $\frac{V}{P}$ (3) PV (4) $PV^3$

**56.** If momentum [P] , area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is :
(1) $\left[PA^{-1}T^0\right]$ (2) $\left[PAT^{-1}\right]$ (3) $\left[PA^{-1}T\right]$ (4) $\left[PA^{-1}T^{-1}\right]$.

**57.** A torque meter is calibrated to reference standards of mass, length and time each with 5% accuracy After calibration , the measured torque with this torque meter will have net accuracy of :
(1) 15% (2) 25% (3) 75% (4) 5%

**58.** An expression of energy density is given by $\mu = \frac{\alpha}{B}\sin\left(\frac{\alpha x}{kt}\right)$, *where* $\alpha, \beta$ are constants, x is displacement, k is Boltzmann constant and t is the temperature. The dimensions of $\beta$ will be:

(1) $\left[ML^2T^{-2}\theta^{-1}\right]$ (2) $\left[M^0L^2T^{-2}\right]$ (3) $\left[M^0L^0T^0\right]$ (4) $\left[M^0L^2T^0\right]$

**59.** The dimensions of $\left(\frac{B^2}{\mu_0}\right)$ will be : (If $\mu_0$ : permeability of free space and B: magnetic field)

(1) $\left[ML^2T^{-2}\right]$ (2) $\left[MLT^{-2}\right]$ (3) $\left[ML^{-1}T^{-2}\right]$ (4) $\left[ML^2T^{-2}A^{-1}\right]$

**60.** Consider the efficiency of Carnot's engine is given by

$\eta = \frac{\alpha\beta}{\sin\theta}\log_e\frac{\beta x}{kT}$, *where* $\alpha$ *and* $\beta$ are constants. If T is temperature , k is Boltzmann constant, $\theta$ is angular displacement and x has the dimensions of length . Then, choose the incorrect option

(1) Dimensions of $\beta$ is same as that of force

(2) Dimensions of $\alpha^{-1}x$ is same as that of energy

(3) Dimensions of $\eta^{-1}\sin\theta$ is same as that of $\alpha\beta$

(4) Dimensions of $\alpha$ is same as that of $\beta$

**61.** Given below are two statements: One is labelled as Assertion (1) and other is labelled as

**Assertion (1):** Time period of oscillation of a liquid drop depends on surface tension (S), if density of the liquid is p and radius of the drop is r, then $T = k\sqrt{pr^3 / S^{3/2}}$ is dimensionally correct, Where K is dimensionless

**Reason (R):** Using dimensional analysis we get R.H.S having different dimension than that of time period

In the light of above statements, choose the correct answer from the options given below

A) Both (1) and (R) are true and (R) is the correct explanation of (1)

B) Both (1) and (R) are true but (R) is not the correct explanation of (1)

C) (1) is true but (R) is false

D) (1) is false but (R) is true

**62.** If speed V, area A and force F are chosen as fundamental units, then the dimension of young's modulus will be

(1) $FA^{-1}V^0$ (2) $FA^2V^{-1}$ (3) $FA^2V^{-2}$ (4) $FA^2V^{-3}$

**63.** If momentum (P) , area(1) and time (T) are taken to be the fundamental quantities then the dimensional formula for energy is

(1) $\left[P^{\frac{1}{2}}AT^{-1}\right]$ (2) $\left[P^{2}AT^{-2}\right]$ (3) $\left[PA^{\frac{1}{2}}T^{-1}\right]$ (4) $\left[PA^{-1}T^{-2}\right]$

**64.** Amount of solar energy received on the earth's surface per unit time is defined a solar constant Dimensions of solar constant is

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

**65.** Dimensional formula for thermal conductivity is (here k denotes the temperature)

(1) $MLT-2K^{-2}$ (2) $MLT^{-3}K^{-1}$ (3) $MLT^{-3}K$ (4) $MLT^{-2}K$

**66.** A quantity x is given by $\left(IF\upsilon^2 / WL^4\right)$ in terms of moment of inertia I, force F, velocity V, work W and length L. The dimensional formula for x is same as that of

(1) Coefficient of viscosity (2) Force constant
(3) Energy density (4) Planck's constant

**67.** The dimensions of $\frac{B^2}{2\mu_0}$ , Where B is magnetic field and $\mu_0$ is the magnetic permeability of vacuum is

(1) $ML^{-1}T^{-2}$ (2) $ML^2T^{-2}$ (3) $ML^{-1}T^2$ (4) $ML^{-2}T^{-1}$

**68.** Stopping potential depends on planks constant (h) , current (I) , Universal gravitational constant (G) and speed of light (3) . Choose the correct option for the dimension of stopping potential (V)

(1) $hI^{-1}G^1C^5$ (2) $h^{-1}I^1G^{-1}C^6$ (3) $h^0I^1G^1C^6$ (4) $h^0I^{-1}G^{-1}C^5$

**69.** A quantity f is given by $f=\sqrt{\frac{hc^5}{G}}$ Where C is speed of light , G Universal gravitational constant and h is the plank's constant. Dimension of f is that of :

(1) Momentum (2) Energy (3) Force (4) Pressure

**70.** The frequency (v) of an oscillating liquid drop may depend upon radius (r) of the drop, density ($\rho$) of liquid and the surface tension (s) of the liquid as : $v=r^a\ \rho^b\ s^c$ . The values of a,b and c respectively are

(1) $\left(-\frac{3}{2},-\frac{1}{2},\frac{1}{2}\right)$ (2) $\left(\frac{3}{2},-\frac{1}{2},\frac{1}{2}\right)$ (3) $\left(\frac{3}{2},\frac{1}{2},-\frac{1}{2}\right)$ (4) $\left(-\frac{3}{2},\frac{1}{2},\frac{1}{2}\right)$

**71.** The equation of a circle is given by $x^2 + y^2 = a^2$ , Where a is the radius if the equation is modified to change the origin other than (0,0) then find out the correct dimension of A and B in a new equation : $\left(x - At\right)^2 + \left(y - \frac{t}{B}\right)^2 = a^2$

The dimension of t is given as $\left[T^{-1}\right]$

(1) A=$\left[L^{-1}T\right], B = \left[LT^{-1}\right]$ (2) A=$\left[LT\right], B = \left[L^{-1}T^{-1}\right]$

(3) $\left[L^{-1}T^{-1}\right], B = \left[LT^{-1}\right]$ (4) $\left[L^{-1}T^{-1}\right], B = \left[LT\right]$

**72.** If R, $X_L and X_C$ represent resistance, inductive reactance and capacitive reactance. Then which of the following is dimensionless :

(1) $R X_L X_C$ (2) $\frac{R}{\sqrt{X_L X_C}}$ (3) $\frac{R}{X_L X_C}$ (4) $R\frac{X_L}{X_C}$

**73.** $\left(P + \frac{a}{V^2}\right)\left(V - b\right) = RT$ represents the equation of state of some gases. Where P is the pressure , V is the volume, T is the temperature and a,b and R are the constants. The physical quantity , which has dimensional formula as that of $\frac{b^2}{a}$, will be :

(1) Bulk modulus (2) Modulus of rigidity

(3) Compressibility (4) Energy density

**74.** If the velocity of light c, universal gravitational constant G and planck's constant h are chosen as fundamental quantities The dimensions of mass in the new system is:

(1) $\left[h^{\frac{1}{2}}c^{\frac{1}{2}}G^{1}\right]$ (2) $\left[h^{1}c^{1}G^{-1}\right]$ (3) $\left[h^{\frac{1}{2}}c^{\frac{1}{2}}G^{\frac{1}{2}}\right]$ (4) $\left[h^{\frac{1}{2}}c^{\frac{1}{2}}G^{\frac{1}{2}}\right]$

**75.** If the acceleration due to gravity is $10\,ms^{-2}$ and the units of length and time are changed in kilometre and hour respectively, the numerical value of the acceleration is [Kerala PET 2002]

(1)360000 (2)72,000 (3)36,000 (4)129600

**76.** If $L, C$ and $R$ represent inductance, capacitance and resistance respectively, then which of the following does not represent dimensions of frequency [IIT 1984]

(1) $\frac{1}{RC}$ (2) $\frac{R}{L}$ (3) $\frac{1}{\sqrt{LC}}$ (4) $\frac{C}{L}$

**77.** Number of particles is given by $n = -D\frac{n_2 - n_1}{x_2 - x_1}$ crossing a unit area perpendicular to $X$-axis in unit time, where $n_1$ and $n_2$ are number of particles per unit volume for the value of $x$ meant to $x_2$ and $x_1$. Find dimensions of $D$ called as diffusion constant [CPMT 1979]

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

**78.** With the usual notations, the following equation $S_t = u + \frac{1}{2}a(2t-1)$ is

(1) Only numerically correct
(2) Only dimensionally correct
(3) Both numerically and dimensionally correct
(4) Neither numerically nor dimensionally correct

**79.** A highly rigid cubical block $A$ of small mass $M$ and side $L$ is fixed rigidly onto another cubical block $B$ of the same dimensions and of low modulus of rigidity $\eta$ such that the lower face of $A$ completely covers the upper face of $B$. The lower face of $B$ is rigidly held on a horizontal surface. A small force $F$ is applied perpendicular to one of the side faces of $A$. After the force is withdrawn block $A$ executes small oscillations. The time period of which is given by [IIT 1992]

(1) $2\pi\sqrt{\frac{M\eta}{L}}$ (2) $2\pi\sqrt{\frac{L}{M\eta}}$ (3) $2\pi\sqrt{\frac{ML}{\eta}}$ (4) $2\pi\sqrt{\frac{M}{\eta L}}$

**80.** In the relation $P = \frac{\alpha}{\beta}e^{-\frac{\alpha Z}{k\theta}}$ $P$ is pressure, $Z$ is the distance, $k$ is Boltzmann constant and $\theta$ is the temperature. The dimensional formula of $\beta$ will be [IIT (Screening) 2004]

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

# KEYS AND SOLUTIONS:

1. KEY: 1

SOL: unit of $\frac{E}{H} is \frac{Volt / metre}{Ampere / metre} = \frac{Volt}{Ampere} = ohm$

2. KEY: 2

SOL: $\vec{E} = \frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j}$

$$\left[\frac{A}{x^2}\right] = NC^{-1} \Rightarrow [A] = Nm^2C^{-1}$$

3. C
4. C
5. B
6. C
7. B
8. D
9. C
10. A
11. C
12. C
13. B
14. B
15. KEY: C

SOL: Least count of V.C= $\left(1-\frac{9}{10}\right)\times 1mm$

=0.1 mm

$\therefore zero\,error = 7\times 0.1 = 0.7\,mm$

$positive\,error$

$Measured\,value = (31 + 4\times 0.1)mm$

=31.4 mm

$\therefore Length\,of\,cylinder = 31.4 - 0.7$

=30.7mm

=3.07cm

16. KEY: A

SOL: Least count = $\frac{0.1}{50}cm$

=0.002cm

Thickness of objects = Main scale Reading +Circular scale reading x least count

17. KEY: B

SOL: L.C.=$\frac{0.5mm}{50}$ $=10^{-2}mm=10^{-5}m=10\mu m$

18. KEY: B

SOL: Pitch= $\frac{3}{6}=0.5mm$

$$L.C.=\frac{0.5mm}{50}=\frac{1}{100}mm=0.01mm=0.001cm$$

19. Sol:B

Length of the rod = observed reading – zero error

$=(\text{Main scale division + Vernier Scale division} \times \text{L.C}) - \text{Zero error}$

$=(6.4+8\times 0.01)-(-0.04)$

$=6.4+0.08+0.04$

$=6.52$ cm

20. SOL:C

Pitch = 1 mm

Number of division on circular scale = 200

$$\text{L.C} = \frac{\text{Pitch}}{\text{Number of division on circular scale}}$$

$$=\frac{1\text{ mm}}{200}=0.005\text{ mm}=0.0005\text{ cm}$$

Diameter of the wire = (Main scale division + Circular Scale $\times$ L.C) – Zero error

= 6 mm + 45 $\times$ 0.005 – (-0.05)

= 6 mm +0.225 mm + 0.05 mm = 6.275 mm

21. SOL:A

VS=4, MS=2.7

= MS+VS x LC =2.7 + 0.04=2.74

22. SOL:2

Reading $=\text{MSR}+n(\text{L.C})$

$=8\text{ mm}+37(0.01\text{ mm})$

$=0.837$ cm.

23. KEY: 1

24. 4

25. key: 1

SOL: $\Delta Y=6.47\times 10^{9}N/m^{2}$ $Y=2.24\times 10^{11}N/m^{2}$

26. SOL : D
27. SOL: C
28. SOL: D
29. SOL: B
30. SOL: B
31. KEY: B

SOL: $X = 3YZ^2$

$$[Y] = \frac{[X]}{[Z^2]}$$

$[X] = \dim ension\, of\ capaci \tan ce$

$$C = \frac{Q}{V} = \frac{Q}{W}Q$$

$$B = \frac{F}{IL} = \frac{Ft}{QL}$$

$$[B] = [Z] = \frac{[MLT^{-2}][T]}{[Q][L]}$$

$$[Z] = [MT^{-1}Q^{-1}]$$

$$[Y] = \frac{[M^{-1}L^{-2}T^2Q^2]}{[MT^{-1}Q^{-1}]^2} = [M^{-3}L^{-2}T^{-2}Q^2]$$

$$C = \frac{Q^2}{W}$$

$$[C] = [X] = \frac{Q^2}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^2Q^2]$$

$$C = \frac{Q^2}{W}$$

$$[C] = [X] = \frac{Q^2}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^2Q^2]$$

$[Z] = \dim ension\, of\ magnetic\, induction$

32. KEY: C

SOL: Dimension of $1/2\ t_0\ E^2 = [t_0][E^2]$

$$[t_0]=\left[M^{-1}L^{-3}T^{4}I^{2}\right]$$

$$[E]=\left[M^{1}L^{1}T^{-3}I^{-1}\right]$$

33. Key: D

Sol: $x=t_0L\dfrac{\Delta v}{\Delta t}$

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

*Dimension of current*

$$p=\left[\frac{\alpha}{\beta}\right]=\left[\frac{k\theta}{z\beta}\right]$$

$$[\beta]=\left[\frac{k\theta}{zp}\right][k\theta]=[Energy]$$

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

34. KEY: C

SOL: $P=\dfrac{\alpha}{\beta}\exp\left(-\dfrac{\alpha z}{k\theta}\right)$

exponent is dimensionless quantity

$$\left[\frac{\alpha z}{k\theta}\right]=\left[M^{0}L^{0}T^{0}\right]$$

$$[\alpha]=\left[\frac{k\theta}{z}\right]$$

35. KEY: D

SOL: By checking dimension all option

[Dipole moment] = $[M^{0}L^{1}T^{1}A^{1}]$

[Electric Flux] = $[M^{1}L^{3}T^{-3}I^{-1}]$

[Electric field] = $[M^{1}L^{1}T^{-3}I^{-1}]$

36. Key: B

Sol: $\omega_\rho=\omega_\rho=\sqrt{\dfrac{Ne^2}{Mt_0}}$.

$$=\sqrt{\frac{4\times10^{27}\times\left(1.6\times10^{-19}\right)^2}{10^{-30}\times10^{-11}}}$$

$$=\sqrt{10.24\times10^{30}}$$

$$\omega_\rho=3.2\times10^{15}$$

$$f_P=\frac{3.2\times10^{15}}{2\pi}=0.51\times10^{15}$$

$$c=fd$$

$$\lambda=\frac{c}{f}$$

$$=\frac{3\times10^8}{0.51\times10^{15}}=5.88\times10^{-7}$$

$$=588\times10^{-9}=600\,nm$$

37. KEY: B

SOL: $\frac{\Delta z}{z}=2\frac{\Delta A}{A}+\frac{2}{3}\frac{\Delta b}{b}+\frac{1}{2}\frac{\Delta c}{c}+3\frac{\Delta d}{d}$

$$=2\times2+\frac{2}{3}\times1.5+\frac{1}{2}\times4+3\times2.5=14.5\%$$

38. key: 2

SOL:

$$\rho=\frac{m}{\frac{4}{3}\pi\left(\frac{d}{2}\right)^3}$$

$$\therefore\%\frac{\Delta\rho}{\rho}=\frac{\Delta m}{m}+3.\left(\frac{\Delta d}{d}\right)$$

$$=6+3\times1.5$$

$$=10.5\%$$

$$=\left(\frac{1050}{100}\right)\%$$

39. KEY: B

SOL: $d_{av}=5.5375mm$

$\Delta d=0.07395mm$

$\because$ Measured data are up to two digits after decimal

$\because d=\left(5.54\pm0.07\right)mm$

40. KEY: C

Sol: $\frac{\Delta T}{T}=\frac{1}{2}\left(\frac{\Delta g}{g}+\frac{\Delta L}{L}\right)$

$\frac{\Delta g}{g}=\frac{2\Delta T}{T}+\frac{\Delta L}{L};$

$=2\left(\frac{1}{50}\right)+\frac{0.1}{25.0}=4.4\%$

41. KEY: D

Sol: $A_1+B_1+C_1=24.36+0.0724+256.2=280.6324=281$

$A_2+B_2+C_2=24.44+16.082+240.2=280.722=280.7$

$A_3+B_3+C_3=25.2+19.2812+236.183=280.6642=281$

$A_4+B_4+C4=25+236.191+19.5=280.691=280$

*Answer should be*

$A_4+B_4+C4<A_2+B_2+C_2<A_1+B_1+C_1=A_3+B_3+C_3$

42. Sol: 3

$\frac{\Delta \mathrm{g}}{\mathrm{g}}=\frac{\Delta \mathrm{L}}{\mathrm{L}}+2\frac{\Delta \mathrm{T}}{\mathrm{T}}$

43. SOL: A

Only 4 and 2 are significant and remaining zeros are insignificant

44. KEY: 2

SOL: $[M]=K[F]^a[T]^b[V]^c$

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

$a=1, b=1, c=-1$

$\therefore [M]=\left[FTV^{-1}\right]$

45. KEY: 1

SOL: (i) $\frac{\pi pa^4}{8\eta L}=\frac{dv}{dt}=$ volumetric flow rate (poisceuille's law)

(ii) $h\rho g=\frac{2s}{r}\cos\theta$

(iii) RHS $\Rightarrow \varepsilon\times\frac{1}{4\pi\varepsilon_0}\times\frac{1}{\varepsilon}=\frac{q}{t}\times\frac{1}{r2}=\frac{1}{L^2}=IL^{-2}$

$LHS\ T=\frac{1}{A}=IL^{-2}$

(iv) W= $\tau\theta$

46. KEY: 1

SOL: Density $= \left[F^{a}L^{b}T^{c}\right]$

$\left[ML^{-3}\right]=\left[M^{a}L^{a}T^{-2a}L^{b}T^{c}\right]$

$\left[M^{1}L^{-3}\right]=\left[M^{a}L^{a+b}T^{-2a+c}\right]$

$a=1;\ a+b=-3;\ -2a+c=0$

$1+b=-3\quad c=2a$

$b=-4\quad c=2$

47. KEY: 3

SOL: $[\mu_r]=1\ as\ \mu_r=\dfrac{\mu}{\mu_m}$

$\left[Power\ factor\,(\cos\phi)\right]=1$

$\mu_0=\dfrac{B_0}{H}\left(unit=NA^{-2}\right):Not\ \dim ensionless$

$[\mu_0]=\left[MLT^{-2}A^{-2}\right]$

$quality\ \ factor\,(Q)=\dfrac{Energy\,stored}{Energy\,dissipated\ per\,cycle}$

$So\,Q\,is\,unitless\,\backslash\,\&\dim ensionless$

48. KEY: 4

SOL: $E=ML^{2}T^{-2}$

$L=ML^{2}T^{-1}$

$m=M$

$G=M^{-1}L^{+3}T^{-2}$

$P=\dfrac{EL^{2}}{M^{5}G^{2}}$

$[P]=\dfrac{\left(ML^{2}T^{-2}\right)\left(M^{2}L^{4}T^{-2}\right)}{M^{5}\left(M^{-2}L^{6}T^{-4}\right)}=M^{0}L^{0}T^{0}$

49. KEY: D

SOL: $S=\dfrac{Q}{M\Delta T}=\dfrac{J}{Kg^{0}C}$

$L=\dfrac{Q}{m}=\dfrac{J}{Kg}$

50. KEY: A

SOL: Velocity gradient = $\frac{dV}{dX} = \frac{1}{S}$

$\lambda = \frac{1}{S}$

51. KEY: C

SOL : $P = \frac{\alpha}{\beta}\log_e\left(\frac{kt}{\beta X}\right)$

$\frac{kt}{\beta X} = 1 \Rightarrow \beta = \frac{kt}{X} = \frac{ML^2T^{-2}}{L}$

$\left(\therefore E = \frac{1}{2}kt\right)$

As P is dimensionless $\Rightarrow [\alpha] = [\beta] = \left[MLT^{-2}\right]$

52. KEY: C

SOL : $e_2$ : induced emf in secondary coil

$i_1$ :Current in primary coil

M : Mutual inductance

$e_2 = -M\frac{di_1}{dt}$

$M = -\frac{e_2}{\frac{di_1}{dt}}$

$$[M] = \frac{[e_2]}{\left[\frac{di_1}{dt}\right]} = \frac{\left[\frac{W}{q}\right]}{\left[\frac{di_1}{dt}\right]} = \frac{\frac{\left[ML^2T^{-2}\right]}{[AT]}}{\left[AT^{-1}\right]}$$

$= \left[ML^2T^{-2}A^{-2}\right]$

53. KEY: A

SOL : Pascal second

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

54. KEY:D

SOL : $\left(\frac{L}{C}\right)$ does not have dimension of time

RC, $\frac{L}{R}$ are time constant While $\sqrt{LC}$ is reciprocal of angular frequency or having dimension of time

55. KEY:C

SOL: By principle of homogeneity

$$[P]=\left[\frac{a}{V^2}\right] and [b]=[V]$$

$$\Rightarrow\left[\frac{a}{b}\right]=[PV](C)$$

56. KEY:A

SOL: Viscosity = Pascal second

$$P^x A^y T^z=\left[M^1L^{-1}T^{-1}\right]$$

$$\left[M^1L^{+1}T^{-1}\right]^x\left[L^2\right]^y\left[T^1\right]^z=M^1L^{-1}T^{-1}$$

$$M^xL^{+x+2y}T^{-x+z}=M^1L^{-1}T^{-1}$$

$$x=1 \;\; x+2y=-1 \;\; -x+z=-1$$

$$y=-1$$

$$z=0$$

$$Vis\cos ity=P^1A^{-1}T^0$$

57. KEY:B

SOL: Dimensional formula for Torque

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

*NOW*

Percentage error in torque

$$=\%\,\tau=\%M+2\%L$$

$$2\%T$$

$$\%\tau=25\%$$

58. KEY:D

SOL: $\frac{\alpha[L]}{\left[ML^1T^{-2}\right]}=\left[M^0L^0T^0\right]$

$$\alpha=\left[ML^1T^{-2}\right]$$

$$\frac{\alpha}{\beta}=\frac{\left[ML^2T^{-2}\right]}{\left[L^3\right]}\Rightarrow\beta=\frac{\left[ML^1T^{-2}\right]\left[L^3\right]}{ML^2T^{-2}}$$

59. KEY:C

SOL: $u = \dfrac{B^2}{2\mu_0}$

$u \to Energy\ per\ unit\ volume$

$$\left[\frac{B^2}{\mu_0}\right] = [u] = \frac{\left[ML^2T^{-2}\right]}{\left[L^3\right]} = \left[ML^{-1}T^{-2}\right]$$

60. KEY:D

SOL: $[\alpha\beta] = [\eta] = [\sin\theta] = Dimensionless$

$\left[\eta^{-1}\sin\theta\right] = [\alpha\beta] = D.L$

61. KEY:D

SOL:

$$T = k\sqrt{\frac{pr^3}{S^{3/2}}}$$

$$Dimensions\ of\ RHS = \frac{\left[M^{1/2}L^{-3/2}\right]\left[L^{3/2}\right]}{\left[MT^{-2}\right]^{3/4}} = M^{1/8}L^0T^{3/2}$$

Dimensions of L.H.S $\neq$ Dimensions of R.H.S

$\therefore$ options (4)

62. KEY: A

SOL: $\therefore [Young's\ \text{mod}ulus] = \left[\dfrac{Force}{Area}\right]$

$\Rightarrow [Young's\ \text{mod}ulus] = FA^{-1}$

$\Rightarrow [Young's\ \text{mod}ulus] = FA^{-1}V^0$

63. KEY: C

SOL: $Energy = Force \times Dis\tan ce$

$$\Rightarrow [Energy] = \frac{P}{T} \times \sqrt{A}$$

$= PT^{-1}A^{1/2}$

64. KEY: D

SOL: Solar constant= $\dfrac{E}{AT}$

$$= \frac{M^1L^2T^{-2}}{L^2T} = M^1T^{-3}$$

65. KEY: B

SOL: $\frac{dQ}{dt}=\frac{KA(\Delta T)}{x}$

$\Rightarrow [K]=\frac{ML^2T^{-2}\times L}{T\times L^2\times K}$

$=MLT^{-3}K^{-1}$

66. KEY: C

SOL: $x=\frac{IF\vartheta^2}{WL^4}$

$\therefore [X]=\frac{\left(ML^2\right)\times\left(MLT^{-2}\right)\times\left(LT^{-1}\right)^2}{\left(ML^2T^{-2}\right)\times L^4}$

$=ML^{-1}T^{-2}$

$=[Energy\, density]$

67. KEY: A

SOL: Energy density in magnetic field $=\frac{B^2}{2\mu_o}$

$=\frac{Force\times displacement}{(displacement)^3}=\frac{MLT^{-2}L}{L^3}=ML^{-1}T^{-2}$

68. KEY: D

SOL: $V=K(h)^a(I)^b(G)^c(C)^d$ $(V\, is\, voltage)$

$[h]=ML^2T^{-1}$

$[I]=A$

$[G]=M^{-1}L^3T^{-2}$

$[C]=LT^{-1}$

$[V]=ML^2T^{-3}A^{-1}$

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

$ML^2T^{-3}A^{-1}=M^{a-c}L^{2a+3c+d}T^{-a-2c-d}A^b$

$a-c=1......(1)$

$2a+3c+d=2...(2)$

$-a-2c-d=-3...(3)$

$b=-1.....(4)$

*on solving*

$c=-1$

$a=0$

$d=5, b=-1$

$V=K(h)^{0}(I)^{-1}(G)^{-1}(C)^{5}$

69. KEY: B

Sol: $\left[ML^{2}T^{-2}\right]$

$[hc]=\left[ML^{3}T^{-2}\right]$

$[c]=\left[LT^{-1}\right]$

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

70. KEY: 2

SOL: $\left[T^{-1}\right]=\left[L^{1}\right]^{a}\left[M^{1}L^{-3}\right]^{b}\left[\frac{MLT^{-2}}{L}\right]^{c}$

$\Rightarrow T^{-1}=M^{b+c}.L^{a-3b}.T^{-2C}$

$C=\frac{1}{2}, b=-\frac{1}{2}, A-3b=0$

$a+\frac{3}{2}=0 \Rightarrow a=-\frac{3}{2}$

71. KEY: 2

SOL: $(X-At)^{2}+\left(y-\frac{t}{B}\right)=a^{2}$

$[At] = A \times \frac{1}{T} = L$

$\therefore [A] = T^1 L^1$

$\frac{t}{B} is\, in\, meters$

$\therefore \frac{1}{T[B]} = L$

$\therefore [B] = T^{-1} L^{-1}$

$\therefore Correct\, ans(2)$

72. KEY: 2

SOL: All three have same dimension therefore $\frac{R}{\sqrt{X_L X_C}}$ is dimensionless

73. KEY: 3

SOL: $[b] = [V]$

$\left[\frac{a}{b^2}\right] = [P]$ $\therefore \left[\frac{b^2}{a}\right] = \frac{1}{[P]} = \frac{1}{[B]} = [K]$

74. KEY: 4

SOL: Say dimensional formale of mass is $H^x C^y G^z$

$M^1 = \left(ML^2T^{-1}\right)^x \left(LT^{-1}\right)\left(M^{-1}L^3T^{-2}\right)^z$

$M^1 L^0 T^0 = M^{x-z} L^{2x+y+3z} T^{-x-y-2z}$

On comparing both sides

x-z=1

2x+y+3z=0

-x-y-2z=0

On solving above equations we get

$x = \frac{1}{2}\ y = \frac{1}{2}\ z = \frac{-1}{2}$

75. SOL: (4) $n_2 = n_1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2} = 10\left[\frac{meter}{km}\right]^1\left[\frac{\sec}{hr}\right]^{-2}$

$n_2 = 10\left[\frac{m}{10^3 m}\right]^1\left[\frac{\sec}{3600 \sec}\right]^{-2} = 129600$

76. SOL: (4) $f = \frac{1}{2\pi\sqrt{LC}}$ $\therefore \left(\frac{C}{L}\right)$ does not represent the dimension of frequency

77. SOL: (4) $f = \frac{1}{2\pi\sqrt{LC}}$ $\therefore \left(\frac{C}{L}\right)$ does not represent the dimension of frequency

78. SOL: (3) We can derive this equation from equations of motion so it is numerically correct.

$S_t$ = distance travelled in $t^{th}$ second = $\frac{\text{Distance}}{\text{time}} = [LT^{-1}]$

$u$ = velocity = $[LT^{-1}]$ and $\frac{1}{2}a(2t-1) = [LT^{-1}]$

As dimensions of each term in the given equation are same, hence equation is dimensionally correct also

79. SOL: (4) By substituting the dimensions of mass [M], length [L] and coefficient of rigidity $\left[ML^{-1}T^{-2}\right]$ we get $T = 2\pi\sqrt{\frac{M}{\eta L}}$ is the right formula for time period of oscillations

80. SOL: (1) In given equation, $\frac{\alpha z}{k\theta}$ should be dimensionless

$\therefore\ \alpha = \frac{k\theta}{z} \Rightarrow [\alpha] = \frac{[ML^2T^{-2}K^{-1} \times K]}{[L]} = [MLT^{-2}]$

and $P = \frac{\alpha}{\beta} \Rightarrow [\beta] = \left[\frac{\alpha}{p}\right] = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]} = [M^0L^2T^0]$.

# Exercise-2

## Physical quantities and units

81. Least count of two screw gauges is same. Then
A) Number of circular divisions on them may be same
B) Number of circular divisions on them may be different
C) Pitch of their screw may be same
D) Pitch of their screw may be different

82. A Vernier scale measured the lengths of two objects and the readings measured by it are same. Then the correct statements are
A) Their actual lengths are same
B) Their actual lengths are different
C) Their actual lengths may be same
D) Their actual lengths may be different

83. The edge of a cube is measured by a Vernier callipers whose 10 Vernier scale divisions coincides with 9 main scale divisions and 1 main scale division is equal to 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 gm. Then,
A) The volume of cube is appropriate significant figures is $1.03\ cm^3$
B) The volume of cube in appropriate significant figures is $1.030\ cm^3$
C) The density of cube in appropriate significant figures is $2.656\ gm/c.c$
D) The density of cube in appropriate significant figures is $2.66\ gm/c.c$

84. The pairs of physical quantities that have the same dimensions are:
(1) Reynolds number and coefficient of friction
(2) Latent heat and gravitational potential
(3) curie and frequency of light wave
(4) Planck's constant and torque
[JEE - 1995'2/100]

85. Which of the following pairs have same dimensions:
(1) Torque and work
(2) Angular momentum and work
(3) Energy and young's modulus
(4) Light year and wavelength [JEE-1996' 2/100]

86. The SI unit of inductance, the henry can be written as: [JEE-1998' 2/200]
(1) weber/ampere (2) volt-second/ampere
(3) joule/(ampere)2 (4) ohm-second

87. Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of the vacuum, and $[\mu_0]$ that of the permeability of the vacuum. If M = mass, L = length, T = time and I = electric current:
[JEE-1998'2/200]
(1) $[\varepsilon_0] = M^{-1}L^{-3}T^2 I$ (2) $[\varepsilon_0] = M^{-1}L^{-3}T^4 I^2$
(3) $[\mu_0] = MLT^{-2}I^{-2}$ (4) $[\mu_0] = ML^2T^{-1}I$

88. If the dimensions of length are expressed as $G^x c^y h^z$; where $G, c$ and $h$ are the universal gravitational constant, speed of light and Planck's constant respectively, then
[IIT 1992]
(1) $x = \frac{1}{2}, y = \frac{1}{2}$ (2) $x = \frac{1}{2}, z = \frac{1}{2}$ (3) $y = \frac{1}{2}, z = \frac{3}{2}$ (4) $y = -\frac{3}{2}, z = \frac{1}{2}$

**Accuracy; precision of instruments and errors in measurements**

89. Which of the following numbers will become 1.5, after they are rounded – off to two significant digits?
A) 1.4502 B) 1.5502 C) 1.4602 D) 1.5492

90. Choose correct statements
A) The number of significant figures in $0.31 \times 10^3$ m is two.
B) The length and breadth of a rectangular sheet are 4.234 m and 1.00 m then the perimeter of rectangle with correct number of significant figures is 10 m
C) When 97.52m is divided by 2.54 s, the result with correct number of significant figures is 38.393700000.
D) When 0.2 J is subtracted from 7.26 J, the result with correct number of significant figures is 7.1 J.
Dimensions of physical quantities

91. The dimensions of the quantities in one (or more) of the following pairs are the same. Identify the pair(s):
A) torque and work B) angular momentum and work
C) energy and Young's modulus D) light year and wavelength

92. Which of the following is/are dimensionless quantity?
A) Universal gravitational constant B) Power factor
C) Dielectric constant D) Permeability of free space

93. The pair(s) of physical quantities that have the same dimensions, is (are)
[IIT 1995]
(1) Reynolds number and coefficient of friction
(2) Latent heat and gravitational potential
(3) Curie and frequency of a light wave
(4) Planck's constant and torque

# KEYS AND SOLUTIONS:

81. ABCD
82. CD
83. SOL:AD

L.C. of vennier calipers = 1 M.S.D – 1 V.S.D.

= 0.1 mm

Measured value of edge of the cube

$= 10 + 1 \times 0.1 = 10.1\text{mm}$

= 1.01 cm

So, volume $= (1.01)^3 \text{ cc} = 1.03\text{cc}$

(Edge Length is measured upto 3 significant digits so, volume or density should be expressed upto 3 significant digits)

$\rho = \frac{M}{V} = \frac{2.736}{1.03} = 2.6563 \simeq 2.66\text{gm / cc}$

84. KEY: A,B,C

SOL: By checking the dimension in all options.

(1) [Raynables No.] = [Co-efficient of Friction]

= $M^0 L^0 T^0$

(2) [Latent heat] = [Gravitational potential]

= $M^0 L^2 T^{-2}$

(3) [Curie] = [Frequency of light wave]

= $M^0 L^0 T^{-1}$

(4) [Plank's constant] = [M1L2T-1]

[Torque] = [$M^1 L^2 T^{-2}$]

85. KEY: A,D

SOL: By checking pimension in all option -

[Torque] = [work] = [$M^1 L^2 T^{-2}$] and [Light year] = [wavelength] = [$M^0 L^1 T^0$]

86. KEY: A,BC,D

SOL: $V = L\frac{dI}{dt}$

$$L = V\frac{dt}{dI} = \frac{volt - \sec}{Amp.} \quad (B)$$

$$\frac{volt}{Amp} = ohms$$

$L = ohms - \sec$

$\phi = Li$

$L = \frac{\phi}{i} \frac{webt}{Amp}$

$L = \frac{Joule}{(Amp)^2}$

87. KEY: B,C

SOL: Unit of $E_0 = \frac{c^2}{N - m^2}$

$[E_0] = \frac{I^2T^4}{ML^3} = \left[M^{-1}L^{-3}T^4I^2\right]$

$Unit\, of\ No. = V / A^2$

$[u] = \left[M^1L^1T^{-2}I^{-2}\right]$

$\therefore \left[\frac{1}{2}t_0E^2\right] = [t_0][E]^2$

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

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

88. (b, d) Length $\propto G^x c^y h^z$

$L = [M^{-1}L^3T^{-2}]^x \ [LT^{-1}]^y [ML^2T^{-1}]^z$

By comparing the power of $M$, $L$ and $T$ in both sides we get $-x + z = 0$, $3x + y + 2z = 1$ and $-2x - y - z = 0$

By solving above three equations we get

$x = \frac{1}{2}, y = -\frac{3}{2}, z = \frac{1}{2}$

89. Sol:A,C,D

$1.4502 = 1.5, \quad 1.5502 = 1.6, \quad 1.4602 = 1.5, \quad 1.5492 = 1.5$

90. SOL:AD

$P = 2(l + b)$

$= 2(4.234 + 1.00)$

$= 10.4 \text{ m}^2$

$\frac{97.52}{2.54} = 38.4$

$7.26 - 0.2 = 7.1$

91. SOL: AD

For torque and work $\longrightarrow ML^2T^{-2}$

For light year wave length $\longrightarrow L$

92. SOL:BC

Power factor $\cos\phi = \frac{R}{Z}$

Dielectric constant $K = \varepsilon/\varepsilon_0$

93. SOL: (a, b, c) Reynolds number and coefficient of friction are dimensionless.

Latent heat and gravitational potential both have dimension $[L^2T^{-2}]$.

Curie and frequency of a light wave both have dimension $[T^{-1}]$. But dimensions of Planck's constant is $[ML^2T^{-1}]$ and torque is $[ML^2T^{-2}]$

# EXERCISE-3

**Physical quantities and units**

94. Match List-I with List-II

| **List-I** | **List-II** |
|---|---|
| (1) $R_H$ (Rydberg constant) | (i) $kgm^{-1}s^{-1}$ |
| (2) h(Planck's constant) | (ii) $kgm^2s^{-1}$ |
| (3) $\mu_B$ (Magnetic field energy density) | (iii) $m^{-1}$ |
| (4) $\eta$ ( coefficient of viscosity) | (iv) $kgm^{-1}s^{-2}$ |

Choose the most appropriate answer from the options given below:

(1) (1)-(ii), (2)- (iii) , (3)-9iv), (4)-( i )

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

(3) (1)–(iv), (2)-(ii), (3)-( i ), (4)-(iii)

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

95. Match List-I with List-II

| List-I | List-II |
|---|---|
| A. Torque | I. $Nms^{-1}$ |
| B. Stress | II. $J\,kg^{-1}$ |
| C. Latent Heat | III. Nm |
| D. Power | IV. $Nm^{-2}$ |

Choose the correct answer from the options given below:

(1) A-III, B-II, C-I, D-IV (2) A-III, B-IV, C-II, D-I

(3) A-IV, B-I, C-III, D-II (4) A-II, B-III, C-I, D-IV

96. Match List-I with List-II

| LIST-1 | LIST-II |
|---|---|
| A. Surface tension | I. $Kgm^{-1}s^{-1}$ |
| B. Pressure | II. $Kg\,ms^{-1}$ |
| C. Viscosity | III. $Kg\,m^{-1}s^{-2}$ |
| D. Impulse | IV. Kg $s^{-2}$ |

Choose the correct answer from the options given below:

(1) A-IV, B-III, C-II, D-I (2) A-IV, B-III, C-I, D-II

(3) A-III, B-IV, C-I, D-II (4) A-II, B-I, C-III, D-IV

97. Match List-I with List-II

| LIST-I | LIST-II |
|---|---|
| A. Torque | I. $kg\ m^{-1}s^{-2}$ |
| B. Energy density | II. $kg\ ms^{-1}$ |
| C. Pressure gradient | III. $kg\ m^{-2}s^{-2}$ |
| D. Impulse | IV. $kg\ m^{2}s^{-2}$ |

Choose the correct answer from the options given below:

(1) A-IV, B-III, C-I, D-II
(2) A-I, B-IV, C-III, D-II
(3) A-IV, B-I, C-II, D-III
(4) A-IV, B-I, C-III, D-II

98. Some physical quantities are given in List – I and some possible SI units in which these quantities may be expressed are given in List – II. Match the physical quantities in List – I with the units in List – II and select the correct answer using the code given below lists

| | List – I | | List – II |
|---|---|---|---|
| (P) | $GM_eM_s$<br>$G \rightarrow$ universal gravitational constant,<br>$M_e \rightarrow$ mass of the earth,<br>$M_s \rightarrow$ mass of the Sun | (1) | (volt) (coulomb) (metre) |
| (Q) | $\frac{3RT}{M}$<br>$R \rightarrow$ universal gas constant,<br>$T \rightarrow$ absolute temperature,<br>$M \rightarrow$ molar mass | (2) | $(\text{kilogram})(\text{meter})^3(\text{second}$ |
| (R) | $\frac{F^2}{q^2B^2}$ $F \rightarrow$ force,<br>$q \rightarrow$ charge,<br>$B \rightarrow$ magnetic field | (3) | $(\text{meter})^2(\text{second})^{-2}$ |
| (S) | $\frac{GM_e}{R_e}$<br>$G \rightarrow$ universal gravitational constant,<br>$M_e \rightarrow$ mass of the earth,<br>$R_e \rightarrow$ radius of the earth | (4) | $(\text{farad})(\text{volt})^2(\text{kg})^{-1}$ |

A) P-1,2;Q-1,2;R-3,4;S-3,4
B) P-1,2;Q-1,2;R-1,2;S-3,4
C) P-3,4;Q-3,4;R-1,2;S-3,4
D) P-1,2;Q-3,4;R-3,4;S-3,4

99. Where C = capacitance, R = resistance, k = Boltzmann constant, E = electric field, B = magnetic field, T = Absolute temperature, h = Planks constant, c = Speed of light, e = Charge of electron. Match the physical quantities in List – I with their S.I units given in List – II and select the correct answer using the code given below lists

| | List – I | | List – II |
|---|---|---|---|
| (P) | $\frac{e^2}{2\varepsilon_0 hc}$ | (1) | Unit less |
| (Q) | $\sqrt{\frac{R^2C^2}{\mu_0\varepsilon_0}}$ | (2) | Meter |
| (R) | $\frac{3}{2}kT$ | (3) | Joule |
| (S) | $\frac{E}{B}$ | (4) | meter per sec |

A) $P-1;Q-2;R-3;S-4$ B) $P-2;Q-1;R-3;S-4$

C) $P-2;Q-1;R-4;S-3$ D) $P-1;Q-2;R-4;S-3$

Dimensions of physical quantities

100. Match List –I with List-II

| List-I | List-II |
|---|---|
| (1) Torque | i) $MLT^{-1}$ |
| (2) Impulse | (ii) $MT^{-2}$ |
| (3) Tension | (iii) $ML^2T^{-2}$ |
| (4) Surface Tension | (iv) $MLT^{-2}$ |

Choose the most appropriate answer from the option given below :

1) (1) –( iii) , (2) – (i) , (3)-(iv), (4)-(ii)

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

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

101. Match List-I with List-II

| \multicolumn2\|c\|List –I | \multicolumn2c\|List−II | | |
|---|---|---|---|
| (1) | MagneticInduction | (i) | $ML^2T^{-2}A^{-1}$ |
| (2) | MagneticFlux | (ii) | $M^0L^{-1}A$ |
| (3) | MagneticPermeability | (iii) | $MT^{-2}A^{-1}$ |
| (4) | Magnetization | (iv) | $MLT^{-2}A^{-2}$ |

Choose the most appropriate answer from the option given below

(1) (1)-(ii), (2)-(iv), (3)-(i), (4)-(iii) (2)(1)-(ii),(2)−(i),(3)−(iv),(4)−(iii)

(3)(1)−(iii),(2)−(ii),(3)−(iv),(4)−(i) (4) (1)-(iii), (2)-(i), (3)-(iv), (4)-(ii)

102. Match List-I with List-II

| LIST-I | LIST-II |
|---|---|
| A. Planck's constant(h) | I. $\left[M^1L^2T^{-2}\right]$ |
| B. Stopping potential (Vs) | 2. $\left[M^1L^1T^{-1}\right]$ |
| C. Work function $(\phi)$ | 3. $\left[M^1L^2T^{-1}\right]$ |
| D. Momentum (P) | 4. $\left[M^1L^2T^{-3}A^{-1}\right]$ |

103.

| LIST-I | LIST-II |
|---|---|
| A. Young's Modulus(Y) | I. $\left[ML^{-1}T^{-1}\right]$ |
| B. Co-efficient of Viscosity $(\eta)$ | II. $\left[ML^2T^{-1}\right]$ |
| C. Planck's Constant(h) | III. $\left[ML^{-1}T^{-2}\right]$ |
| D. Work Function $(\phi)$ | IV. $\left[ML^2T^{-2}\right]$ |

(1) A-III, B-III, C-IV, D-I (2) A-III, B-I,C-II, D-IV
(3) A-I, B-III, C-IV, D-II (4) A-I, B-II, C-III, D-IV

104. Match List-I with List-II

| LIST-I (Physical Quantity) | LIST-II (Dimensional Formula) |
|---|---|
| A. Pressure gradient | I. $\left[M^0L^2T^{-2}\right]$ |
| B. Energy density | II. $\left[M^1L^{-1}T^{-2}\right]$ |
| C. Electric Field | III. $\left[M^1L^{-2}T^{-2}\right]$ |
| D. Latent heat | IV. $\left[M^1L^1T^{-3}A^{-1}\right]$ |

Choose the correct answer from the options given below:
(1) A-III, B-II, C-I, D-IV (2) A-II,B-III, C-IV,D-I
(3) A-III, B-II, C-IV, D-I (4) A-II, B-III, C-I, D-IV

105. Match List-I with List-II

| LSIT-I | LIST-II |
|---|---|
| A. Angular momentum | I. $\left[ML^2T^{-2}\right]$ |
| B. Torque | II. $\left[ML^{-2}T^{-2}\right]$ |
| C. Stress | III. $\left[ML^2T^{-1}\right]$ |
| D. Pressure gradient | IV. $\left[ML^{-1}T^{-2}\right]$ |

Choose the correct answer from the options given below :

(1) A-I, B-IV, C-III, D-II
(2) A-III, B-I, C-IV, D-II
(3) A-II, B-III, C-IV, D-I
(4) A-IV, B-II, C-I, D-III

106. 

| Column I | Column II |
|---|---|
| (i) Curie | (1) $MLT^{-2}$ |
| (ii) Light year | (2) $M$ |
| (iii) Dielectric strength | (3) Dimensionless |
| (iv) Atomic weight | (4) $T$ |
| (v) Decibel | (E) $ML^2T^{-2}$ |
| | (F) $MT^{-3}$ |
| | (G) $T^{-1}$ |
| | (H) $L$ |
| | (I) $MLT^{-3}I^{-1}$ |
| | (J) $LT^{-1}$ |

Choose the correct match [IIT 1992]

(1) (i) G, (ii) H, (iii) C, (iv) B, (v) C
(2) (i) D, (ii) H, (iii) I, (iv) B, (v) G
(3) (i) G, (ii) H, (iii) I, (iv) B, (v) G
(4) None of the above

# KEYS AND SOLUTIONS:

94. KEY: 2

SOL: SI unit of Rydbeg const. = $m^{-1}$

SI unit of Plank's const.=$kgm^2s^{-1}$

SI unit of Magnetic field energy density = $kgm^{-1}\ s^{-2}$

SI unit of coeff. of viscosity = $kgm^{-1}\ s^{-1}$

95. KEY:B

SOL: Torque = $F \times r_{\perp}$ Nm

$Stress = \frac{Force}{Area}$ $N/m^2$

$Latent\,heat = \frac{Energy}{Mass}$ $J\,kg^{-1}$

$Power = \frac{Work}{Time}$ $N\,ms^{-1}$

A-III, B-IV, C-II, D-I

96. KEY: 2

SOL: (1) $Surface Tension = \frac{F}{l} = \frac{MLT^{-2}}{L} = ML^{-1}T^{-2}$

$= Kgs^{-2}(IV)$

(2) $\Pr essure = \frac{F}{A} = \frac{MLT^{-2}}{L^2}$

$= Kg\,m^{-1}s^{-2}(III)$

(3) Viscosity = $= \frac{F}{A\left(\frac{dV}{dz}\right)} = \frac{MLT^{-2}}{L^2\left(\frac{LT^{-1}}{L}\right)}$

$= ML^{-1}T^{-1} = Kg\,m^{-1}s^{-2}(I)$

(4) Impulse = $\int Fdt = MLT^{-2} \times T$

$= MLT^{-1} = Kgms^{-1}(II)$

97. KEY: 4

SOL: SOLUTION NOT AVAILABLE

98. SOL:D

99. SOL:A

100. 4) (1)-(iii), (2)-(iv0, (3)-( i ), (4)-(ii)

KEY: 1

SOL: torque $\tau \to ML^2T^{-2}(III)$

Impulse $I \Rightarrow MLT^{-1}(I)$

Tension force $\Rightarrow MLT^{-2}(IV)$

Surface tension $\Rightarrow MLT^{-2}(II)$

101. KEY: 4

SOL: (1) MagneticInduction = $MT^{-A}A^{-}$

(2) Magnetic Flux = $ML^2\ T^{-2}\ A^{-1}$

(3) Magnetic Permeability = $MLT^{-2}\ A^{-2}$

(4) Magnetization = $M^{(0}L^{-1}\ A$

102. KEY: 2

SOL: (1) Planck's constant

Hv=E

$$h = \frac{E}{V} = \frac{M^1L^2T^{-1}}{T^{-1}} = M^1L^2T^{-1}(III)$$

(2) E=qV

$$V = \frac{E}{q} = \frac{M^1L^2T^{-2}}{A^1T^1} = M^1L^2T^{-3}(IV)$$

(3) $\phi$(Work function)=energy

$= M^1L^2T^{-2}$

(4) Momentum ($\rho$)=F.t

$= M^1L^1T^{-2}$

$= M^1L^1T^{-1}$

103. KEY: 2

SOL:

$$Y = \frac{Stress}{strain} = \frac{F/A}{\Delta\ell/\ell} = \frac{\left[MLT^{-2}\right]}{\left[L^2\right]} = \left[ML^{-1}T^{-2}\right]$$

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

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

$$E = hv \Rightarrow h = \frac{E}{v} = \frac{\left[ML^2T^{-2}\right]}{\left[T^{-1}\right]} = \left[ML^2T^{-1}\right]$$

Work function has same dimension as that of energy , so $[\phi]=\left[ML^2T^{-2}\right]$

104. KEY: 3

SOL: Pressure gradient $=\dfrac{dp}{dx}=\dfrac{\left[ML^{-1}T^{-2}\right]}{[L]}$

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

Energy density = $\dfrac{energy}{volume}=\dfrac{\left[ML^2T^{-2}\right]}{\left[L^3\right]}$

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

Electric field = $\dfrac{Force}{charge}=\dfrac{\left[MLT^{-2}\right]}{\left[L^3\right]}$

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

Latent heat=$\dfrac{heat}{mass}=\dfrac{\left[ML^2T^{-2}\right]}{[M]}$

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

105. KEY: 2
SOL: NO SOLUTION

106. SOL: (1)

# EXERCISE-4

## Measurement

107. The pitch of a screw gauge is 1 mm and there are 100 divisions on the circular scale. While measuring the diameter of a wire, the linear scale reads 1mmand 47th division on the circular scale coincides with the reference line. The length of the wire is 5.6 cm. Find the curved surface area (in cm2) of the wire in appropriate number of significant figures. [JEE 2004]

108. The side of a cube is measured by vernier callipers (10 divisions of a vernier scale coincide with 9 divisions of main scale, where 1 division of main scale is 1mm). The main scale reads 10mman 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. [JEE 2005]

## Accuracy; precision of instruments and errors in measurements

109. The least count of a stop watch is $\frac{1}{5}$s. the time of 20 oscillations of a pendulum is measured to be $25$s. the maximum percentage error in the measurement of time period of pendulum in multiples of 0.4% is

110. A wire has a mass $0.3 \pm 0.003$g, radius $0.5 \pm 0.005$mm and length $6 \pm 0.06$ cm. the maximum percentage error in the measurement of its density is:

## Key and solutions:

107. Sol: 2.6 $cm^2$ (in two significant figures)

108. Sol: 2.66 $g/cm^2$

109. 2

Sol: Maximum error = $\pm\frac{1}{5}s$ Percentage error=$\frac{1/5}{25}\times 100 = 0.8\%$

110. 4

Sol:
$$\rho = \frac{m}{\pi r^2 l}$$
$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$$

# EXERCISE -5

Choose any one of the following four responses:

(1) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(2) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(3) If assertion is true but reason is false.

(4) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

**1.** Assertion : '*Light year*' and 'Wavelength' both measure distance.
Reason : Both have dimensions of time.

**2.** Assertion : Light year and year, both measure time.
Reason : Because light year is the time that light takes to reach the earth from the sun.

**3.** Assertion : Force cannot be added to pressure.
Reason : Because their dimensions are different.

**4.** Assertion : Linear mass density has the dimensions of $[M^1L^{-1}T^0]$.
Reason : Because density is always mass per unit volume.

**5.** Assertion : Rate of flow of a liquid represents velocity of flow.
Reason : The dimensions of rate of flow are $[M^0L^1T^{-1}]$.

**6.** Assertion : Units of Rydberg constant $R$ are $m^{-1}$
Reason : It follows from Bohr's formula $\bar{v} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, where the symbols have their usual meaning.

**7.** Assertion : Parallex method cannot be used for measuring distances of stars more than 100 light years away.
Reason : Because parallex angle reduces so much that it cannot be measured accurately.

**8.** Assertion : Number of significant figures in 0.005 is one and that in 0.500 is three.
Reason : This is because zeros are not significant.

**9.** Assertion : Out of three measurements $l = 0.7\ m$; $l = 0.70\ m$ and $l = 0.700\ m$, the last one is most accurate.
Reason : In every measurement, only the last significant digit is not accurately known.

**10.** Assertion : Mass, length and time are fundamental physical quantities.
Reason : They are independent of each other.

**11.** Assertion : Density is a derived physical quantity.
Reason : Density cannot be derived from the fundamental physical quantities.

**12.** Assertion : Now a days a standard *metre* is defined as in terms of the wavelength of light.
Reason : Light has no relation with length.

**13.** Assertion : Radar is used to detect an aeroplane in the sky
Reason : Radar works on the principle of reflection of waves.

**14.** Assertion : Surface tension and surface energy have the same dimensions.
Reason : Because both have the same S.I. unit

**15.** Assertion : In $y = A\sin(\omega t - kx)$, $(\omega t - kx)$ is dimensionless.
Reason : Because dimension of $\omega = [M^0 L^0 T]$.

**16.** Assertion : A.U. is much bigger than Å.
Reason : A.U. stands for astronomical unit and Å stands from *Angstrom*.

**17.** Assertion : When we change the unit of measurement of a quantity, its numerical value changes.
Reason : Smaller the unit of measurement smaller is its numerical value.

**18.** Assertion : Dimensional constants are the quantities whose value are constant.
Reason : Dimensional constants are dimensionless.

**19.** Assertion : In the relation $f = \frac{1}{2l}\sqrt{\frac{T}{m}}$, where symbols have standard meaning, *m* represent linear mass density.
Reason : The frequency has the dimensions of inverse of time.

**20.** Assertion : The graph between *P* and *Q* is straight line, when *P/Q* is constant.
Reason : The straight line graph means that *P* proportional to *Q* or *P* is equal to constant multiplied by *Q*.

**21.** Assertion : Avogadro number is the number of atoms in one gram mole.
Reason : Avogadro number is a dimensionless constant.

**22.** Assertion : *L*/*R* and *CR* both have same dimensions.
Reason : *L*/*R* and *CR* both have dimension of time.

**23.** Assertion : The quantity $(1/\sqrt{\mu_0 \varepsilon_0})$ is dimensionally equal to velocity and numerically equal to velocity of light.
Reason: $\mu_0$ is permeability of free space and $\varepsilon_0$ is the permittivity of free space.

# KEY:

**1.** (3) Light year and wavelength both represents the distance, so both has dimension of length not of time.

**2.** (4) Light year measures distance and year measures time. One light year is the distance traveled by light in one year.

**3.** (1) Addition and subtraction can be done between quantities having same dimension.

**4.** (3) Density is not always mass per unit volume.

**5.** (4) Rate of flow of liquid is expressed as the volume of liquid flowing per second and it has dimension $[L^3 T^{-1}]$.

**6.** (1)

**7.** (1) As the distance of star increases, the parallax angle decreases, and great degree of accuracy is required for its measurement. Keeping in view the practical limitation in measuring the parallax angle, the maximum distance of a star we can measure is limited to 100 light year.

**8.** (3) Since zeros placed to the left of the number are never significant, but zeros placed to right of the number are significant.

**9.** (2) The last number is most accurate because it has greatest significant figure (3).

**10.** (1) As length, mass and time represent our basic scientific notations, therefore they are called fundamental quantities and they cannot be obtained from each other.

**11.** (3) Because density can be derived from fundamental quantities.

**12.** (3) Because representation of standard metre in terms of wavelength of light is most accurate.

**13.** (1) As radar is most accurate instrument used to detect aeroplane in sky based on principle of reflection of radio waves.

**14.** (3) As surface tension and surface energy both have different S.I. unit and same dimensional formula.

**15.** (3) As ω (angular velocity) has the dimension of $[T^{-1}]$ not $[T]$.

**16.** (2) A.U. is used (Astronomical units) to measure the average distance of the centre of the sun from the centre of the earth, while angstrom is used for very short distances. 1 A.U. = $1.5 \times 10^{11} m;\ 1\mathring{A} = 10^{-10} m$.

**17.** (3) We know that $Q = n_1 u_1 = n_2 u_2$ are the two units of measurement of the quantity $Q$ and $n_1$, $n_2$ are their respective numerical values. From relation $Q_1 = n_1 u_1 = n_2 u_2$, $nu$ = constant $\Rightarrow n \propto 1/u$ *i.e.,* smaller the unit of measurement, greater is its numerical value.

**18.** (3) Dimensional constants are the quantities whose value are constant and they posses dimensions. For example, velocity of light in vacuum, universal gravitational constant, Boltzman constant, Planck's constant etc.

(2) From, $f = \frac{1}{2l}\sqrt{\frac{T}{m}},\ f^2 = \frac{T}{4l^2 m}$

or, $m = \frac{T}{4l^2f^2} = \frac{[MLT^{-2}]}{L^2T^{-2}} = \frac{M}{L} = \frac{\text{Mass}}{\text{length}}$ = linear mass density.

**19.** (1) According to statement of reason, as the graph is a straight line, $P \propto Q,$ or $P$ = constant × $Q$

*i.e.* $\frac{P}{Q}$ = constant

**20.** (3) Avogadro number ($N$) represents the number of atoms in 1 gram mole of an element, i.e. it has the dimensions of mole$^{-1}$.

**21.** (1) Unit of quantity (L/R) is Henry/ohm.

As Henry = ohm × sec, hence unit of L/R is sec i.e.

[L/R] = [T].

Similarly, unit of product CR is farad × ohm or,

$\frac{\text{Coulomb}}{\text{Volt}} \times \frac{\text{Volt}}{\text{Amp}}$ or, $\frac{\text{Sec} \times \text{Amp}}{\text{Amp}}$ or, *sec* i.e. [CR] =

[T] therefore [L/R] and [CR] both have the same dimension.

**22.** (2) Both assertion and reason are true but reason is not the correct explanation of assertion.

$[\varepsilon_0] = [M^{-1}L^{-3}T^4I^2]$, $[\mu_0] = [MLT^{-2}I^{-2}]$

$$\Rightarrow \frac{1}{\sqrt{(\mu_0/4\pi) \times 4\pi E_0}} = \sqrt{\frac{9 \times 10^9}{10^{-7}}} = \sqrt{9 \times 10^{16}} = 3 \times 10^8\, m/s.$$

Therefore $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ has dimension of velocity and numerically equal to velocity of light.