Chapter

1

Units, Dimensions 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.*

On the other hand various happenings in life *e.g.*, happiness, sorrow *etc.* are not physical quantities because these can not be measured.

Measurement is necessary to determine magnitude of a physical quantity, to compare two similar physical quantities and to prove physical laws or equations.

A physical quantity is represented completely by its magnitude and unit. For example, 10 *metre* means a length which is ten times the unit of length. Here 10 represents the numerical value of the given quantity and *metre* represents the unit of quantity under consideration. Thus in expressing a physical quantity we choose a unit and then find that how many times that unit is contained in the given physical quantity, *i.e.*

Physical quantity (Q) = Magnitude × Unit $= n \times u$

Where, n represents the numerical value and u represents the unit. Thus while expressing definite amount of physical quantity, it is clear that as the unit(u) changes, the magnitude(n) will also change but product 'nu' will remain same.

i.e. $n\,u$ = constant, or $n_1 u_1 = n_2 u_2 = \text{constant}$; $\therefore \quad n \propto \frac{1}{u}$

i.e. magnitude of a physical quantity and units are inversely proportional to each other .Larger the unit, smaller will be the magnitude.

(1) **Ratio (numerical value only) :** When a physical quantity is the ratio of two similar quantities, it has no unit.

e.g. Relative density = Density of object/Density of water at $4^\circ C$

Refractive index = Velocity of light in air/Velocity of light in medium

Strain = Change in dimension/Original dimension

(2) **Scalar (magnitude only) :** These quantities do not have any direction *e.g.* Length, time, work, energy *etc.*

Magnitude of a physical quantity can be negative. In that case negative sign indicates that the numerical value of the quantity under consideration is negative. It does not specify the direction.

Scalar quantities can be added or subtracted with the help of ordinary laws of addition or subtraction.

(3) **Vector (magnitude and direction) :** These quantities have magnitude and direction both and can be added or subtracted with the help of laws of vector algebra *e.g.* displacement, velocity, acceleration, force *etc.*

Fundamental and Derived Quantities

(1) **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.

(2) **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.

If length is defined as a fundamental quantity then area and volume are derived from length and are expressed in term of length with power 2 and 3 over the term of length.

Note : ❑ In mechanics, Length, Mass and Time are arbitrarily chosen as fundamental quantities. However this set of fundamental quantities is not a unique choice. In fact any three quantities in mechanics can be termed as fundamental as all other quantities in mechanics can be expressed in terms of these. *e.g.* if speed and time are taken as fundamental quantities, length will become a derived quantity because then length will be expressed as Speed × Time. and if force and acceleration are taken as fundamental quantities, then mass will be defined as Force / acceleration and will be termed as a derived quantity.

Fundamental and Derived Units

Normally each physical quantity requires a unit or standard for its specification so it appears that there must be as many units as there are physical quantities. However, it is not so. It has been found that if in *mechanics* we choose arbitrarily units of any *three* physical quantities we can express the units of all other physical quantities in mechanics in terms of these. Arbitrarily the physical quantities *mass, length* and *time* are chosen for this purpose. *So any unit of mass, length and time in mechanics is called a* **fundamental, absolute or base unit.** *Other units which can be expressed in terms of fundamental units, are called derived units.* For example light year or km is a fundamental unit as it is a unit of length while s^{-1}, m^2 or kg/m are derived units as these are derived from units of time, mass and length.

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

Table 1.1 : 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.

Note : ❑ Apart from fundamental and derived units we also use practical units very frequently. These may be fundamental or derived units *e.g.*, light year is a practical unit (fundamental) of distance while horse power is a practical unit (derived) of power.

❑ Practical units may or may not belong to a system but can be expressed in any system of units

e.g., 1 mile = 1.6 *km* = 1.6×10^{3} *m*.

S.I. Prefixes

In physics we deal from very small (*micro*) to very large (*macro*) magnitudes, as one side we talk about the atom while on the other side of universe, *e.g.*, the mass of an electron is 9.1×10^{-31} *kg* while that of the sun is 2×10^{30} *kg*. To express such large or small magnitudes we use the following prefixes :

Table 1.2 : Prefixes and symbol

Power of 10	Prefix	Symbol
10^{18}	exa	*E*
10^{15}	peta	*P*
10^{12}	tera	*T*
10^{9}	giga	*G*
10^{6}	mega	*M*
10^{3}	kilo	*k*
10^{2}	hecto	*h*
10^{1}	deca	*da*
10^{-1}	deci	*d*
10^{-2}	centi	*c*
10^{-3}	milli	*m*
10^{-6}	micro	μ
10^{-9}	nano	*n*
10^{-12}	pico	*p*
10^{-15}	femto	*f*
10^{-18}	atto	*a*

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 5.0188×10^{25} atoms of ${}_{6}C^{12}$ (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 = 1*XU* = 10^{-13} *m*

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

(iv) 1 micron = μ*m* = 10^{-6} *m*

(v) 1 astronomical unit = 1 *A.U.* = 1.49×10^{11} *m*

$\approx 1.5 \times 10^{11}$ *m* $\approx 10^{8}$ *km*

(vi) 1 Light year = 1 *ly* = 9.46×10^{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 = 2.8×10^{30} *kg*

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

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

(iv) Atomic mass unit (*amu*) : *amu* = 1.67×10^{-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 $= \dfrac{1}{365.25}$ 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.

To make it more clear, consider the physical quantity force

Force = mass × acceleration

$= \dfrac{\text{mass} \times \text{velocity}}{\text{time}}$

$= \dfrac{\text{mass} \times \text{length/time}}{\text{time}}$

= mass × length × (time)$^{-2}$ ... (i)

Thus, the dimensions of force are 1 in mass, 1 in length and – 2 in time.

Here the physical quantity that is expressed in terms of the basic quantities is enclosed in square brackets to indicate that the equation is among the dimensions and not among the magnitudes.

Thus equation (i) can be written as [force] = $[MLT^{-2}]$.

Such an expression for a physical quantity in terms of the fundamental quantities is called the dimensional equation. If we consider only the R.H.S. of the equation, the expression is termed as dimensional formula.

Thus, dimensional formula for force is, $[MLT^{-2}]$.

Quantities Having same Dimensions

Dimension	Quantity
$[M^0L^0T^{-1}]$	Frequency, angular frequency, angular velocity, velocity gradient and decay constant
$[M^1L^2T^{-2}]$	Work, internal energy, potential energy, kinetic energy, torque, moment of force
$[M^1L^{-1}T^{-2}]$	Pressure, stress, Young's modulus, bulk modulus, modulus of rigidity, energy density
$[M^1L^1T^{-1}]$	Momentum, impulse
$[M^0L^1T^{-2}]$	Acceleration due to gravity, gravitational field intensity
$[M^1L^1T^{-2}]$	Thrust, force, weight, energy gradient
$[M^1L^2T^{-1}]$	Angular momentum and Planck's constant
$[M^1L^0T^{-2}]$	Surface tension, Surface energy (energy per unit area)
$[M^0L^0T^0]$	Strain, refractive index, relative density, angle, solid angle, distance gradient, relative permittivity (dielectric constant), relative permeability etc.
$[M^0L^2T^{-2}]$	Latent heat and gravitational potential
$[ML^2T^{-2}\theta^{-1}]$	Thermal capacity, gas constant, Boltzmann constant and entropy
$[M^0L^0T^1]$	$\sqrt{l/g}, \sqrt{m/k}, \sqrt{R/g}$, where l = length g = acceleration due to gravity, m = mass, k = spring constant, R = Radius of earth
$[M^0L^0T^1]$	L/R, $\sqrt{LC}$, RC where L = inductance, R = resistance, C = capacitance
$[ML^2T^{-2}]$	$I^2Rt, \dfrac{V^2}{R}t, VIt, qV, LI^2, \dfrac{q^2}{C}, CV^2$ where I = current, t = time, q = charge, L = inductance, C = capacitance, R = resistance

Important Dimensions of Complete Physics

Heat

Quantity	Unit	Dimension
Temperature (T)	*Kelvin*	$[M^0L^0T^0\theta^1]$
Heat (Q)	*Joule*	$[ML^2T^{-2}]$
Specific Heat (c)	*Joule/kg-K*	$[M^0L^2T^{-2}\theta^{-1}]$
Thermal capacity	*Joule/K*	$[ML^2T^{-2}\theta^{-1}]$
Latent heat (L)	*Joule/kg*	$[M^0L^2T^{-2}]$
Gas constant (R)	*Joule/mol-K*	$[ML^2T^{-2}\theta^{-1}]$
Boltzmann constant (k)	*Joule/K*	$[ML^2T^{-2}\theta^{-1}]$
Coefficient of thermal conductivity (K)	*Joule/m-s-K*	$[MLT^{-3}\theta^{-1}]$
Stefan's constant (σ)	*Watt/m^2-K^4*	$[M^1L^0T^{-3}\theta^{-4}]$
Wien's constant (b)	*Metre-K*	$[M^0L^1T^0\theta]$
Planck's constant (h)	*Joule-s*	$[ML^2T^{-1}]$
Coefficient of Linear Expansion (α)	*Kelvin*$^{-1}$	$[M^0L^0T^0\theta^{-1}]$
Mechanical equivalent of Heat (J)	*Joule/Calorie*	$[M^0L^0T^0]$
Vander wall's constant (a)	*Newton-m^4*	$[ML^5T^{-2}]$
Vander wall's constant (b)	*m^3*	$[M^0L^3T^0]$

Electricity

Quantity	Unit	Dimension
Electric charge (q)	*Coulomb*	$[M^0L^0T^1A^1]$
Electric current (I)	*Ampere*	$[M^0L^0T^0A^1]$
Capacitance (C)	*Coulomb/volt or Farad*	$[M^{-1}L^{-2}T^4A^2]$
Electric potential (V)	*Joule/coulomb*	$[ML^2T^{-3}A^{-1}]$
Permittivity of free space (ε)	$\dfrac{\text{Coulomb}^2}{\text{Newton - metre}^2}$	$[M^{-1}L^{-3}T^4A^2]$
Dielectric constant (K)	Unitless	$[M^0L^0T^0]$
Resistance (R)	*Volt/Ampere* or *ohm*	$[ML^2T^{-3}A^{-2}]$

Quantity	Unit	Dimension
Resistivity or Specific resistance (ρ)	*Ohm-metre*	$[ML^3T^{-3}A^{-2}]$
Coefficient of Self-induction (L)	$\frac{volt-second}{ampere}$ or *henry* or *ohm-second*	$[ML^2T^{-2}A^{-2}]$
Magnetic flux (ϕ)	*Volt-second* or *weber*	$[ML^2T^{-2}A^{-1}]$
Magnetic induction (B)	$\frac{newton}{ampere-metre}$ $\frac{Joule}{ampere-metre^2}$ $\frac{volt-second}{metre^2}$ or *Tesla*	$[ML^0T^{-2}A^{-1}]$
Magnetic Intensity (H)	*Ampere/metre*	$[M^0L^{-1}T^0A^1]$
Magnetic Dipole Moment (M)	*Ampere-metre*	$[M^0L^2T^0A^1]$
Permeability of Free Space (μ)	$\frac{Newton}{ampere^2}$ or $\frac{Joule}{ampere^2-metre}$ or $\frac{Volt-second}{ampere-metre}$ or $\frac{Ohm-second}{metre}$ or $\frac{henry}{metre}$	$[MLT^{-2}A^{-2}]$
Surface charge density (σ)	$Coulomb\,metre^{-2}$	$[M^0L^{-2}T^1A^1]$
Electric dipole moment (p)	$Coulomb-metre$	$[M^0L^1T^1A^1]$
Conductance (G) ($1/R$)	ohm^{-1}	$[M^{-1}L^{-2}T^3A^2]$
Conductivity (σ) ($1/\rho$)	$ohm^{-1}metre^{-1}$	$[M^{-1}L^{-3}T^3A^2]$
Current density (J)	*Ampere/m²*	$M^0L^{-2}T^0A^1$
Intensity of electric field (E)	*Volt/metre, Newton/coulomb*	$M^1L^1T^{-3}A^{-1}$
Rydberg constant (R)	m^{-1}	$M^0L^{-1}T^0$

Application of Dimensional Analysis

(1) **To find the unit of a physical quantity in a given system of units** : To write the definition or formula for the physical quantity we find its dimensions. Now in the dimensional formula replacing M, L and T by the fundamental units of the required system we get the unit of physical quantity. However, sometimes to this unit we further assign a specific name,

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 cm²/s²* which is called *erg* while in M.K.S. system will be *kg-m²/s²* which is called *joule*.

(2) **To find dimensions of physical constant or coefficients** : As dimensions of a physical quantity are unique, we write any formula or equation incorporating the given constant and then by substituting the dimensional formulae of all other quantities, we can find the dimensions of the required constant or coefficient.

(i) Gravitational constant : According to Newton's law of gravitation

$$F = G\frac{m_1m_2}{r^2} \text{ or } G = \frac{Fr^2}{m_1m_2}$$

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

$$\frac{dV}{dt} = \frac{\pi pr^4}{8\eta l} \text{ or } \eta = \frac{\pi pr^4}{8l(dV/dt)}$$

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 $n_1[u_1] = n_2[u_2]$

$$\Rightarrow n_1[M_1^aL_1^bT_1^c] = n_2[M_2^aL_2^bT_2^c]$$

$$\Rightarrow n_2 = n_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c$$

where M_1, L_1 and T_1 are fundamental units of mass, length and time in the first (known) system and M_2, L_2 and T_2 are fundamental units of mass, length and time in the second (unknown) system. Thus knowing the values of fundamental units in two systems and numerical value in one system, the numerical value in other system may be evaluated.

Example : (i) conversion of *Newton* into *Dyne*.

The Newton is the S.I. unit of force and has dimensional formula $[MLT^{-2}]$.

So 1 N = 1 *kg-m/sec²*

By using $n_2 = n_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c$

$$= 1\left[\frac{kg}{gm}\right]^1\left[\frac{m}{cm}\right]^1\left[\frac{sec}{sec}\right]^{-2}$$

$$= 1\left[\frac{10^3gm}{gm}\right]^1\left[\frac{10^2cm}{cm}\right]^1\left[\frac{sec}{sec}\right]^{-2} = 10^5$$

$\therefore$ 1 N = 10^5 *Dyne*

(ii) Conversion of gravitational constant (G) from C.G.S. to M.K.S. system

The value of G in C.G.S. system is 6.67×10^{-8} C.G.S. units while its dimensional formula is $[M^{-1}L^3T^{-2}]$

So $G = 6.67 \times 10^{-8}\ cm^3/g\ s^2$

By using $n_2 = n_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c$

$$= 6.67 \times 10^{-8}\left[\frac{gm}{kg}\right]^{-1}\left[\frac{cm}{m}\right]^3\left[\frac{sec}{sec}\right]^{-2}$$

$$= 6.67 \times 10^{-8}\left[\frac{gm}{10^3 gm}\right]^{-1}\left[\frac{cm}{10^2 cm}\right]^3\left[\frac{sec}{sec}\right]^{-2}$$

$$= 6.67 \times 10^{-11}$$

$\therefore\ G = 6.67 \times 10^{-11}$ M.K.S. units

(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.

(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 (2π) through experiments so $T = 2\pi\sqrt{\frac{l}{g}}$

(ii) Stoke's law : When a small sphere moves at low speed through a fluid, the viscous force F, opposes the motion, is found experimentally to depend on the radius r, the velocity of the sphere v and the viscosity η of the fluid.

So $F = f(\eta, r, v)$

If the function is product of power functions of η, r and v, $F = K\eta^x r^y v^z$; where K is dimensionless constant.

If the above relation is dimensionally correct

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

or $[MLT^{-2}] = [M^xL^{-x+y+z}T^{-x-z}]$

Equating the exponents of similar quantities

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

Solving these for x, y and z, we get $x = y = z = 1$

So equation (i) becomes $F = K\eta rv$

On experimental grounds, $K = 6\pi$; so $F = 6\pi\eta rv$

This is the famous Stoke's law.

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 2π *etc.* cannot be deduced by the methods of dimensions.

(3) The method of dimensions can not be used to derive relations other than product of power functions. For example,

$$s = ut + (1/2)at^2 \text{ or } y = a\sin\omega t$$

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 $T = 2\pi\sqrt{I/mgl}$ can not 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 : 1.32×10^{-2} has three significant figures.

1.32×10^{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.

Example : $x = 7.82$ is rounded off to 7.8,

again $x = 3.94$ is rounded off to 3.9.

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

Example : x = 6.87 is rounded off to 6.9,

again x = 12.78 is rounded off to 12.8.

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

Example : x = 16.351 is rounded off to 16.4,

again x = 6.758 is rounded off to 6.8.

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

Example : x = 3.250 becomes 3.2 on rounding off,

again x = 12.650 becomes 12.6 on rounding off.

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

Example : x = 3.750 is rounded off to 3.8,

again x = 16.150 is rounded off to 16.2.

Significant Figures in Calculation

In most of the experiments, the observations of various measurements are to be combined mathematically, *i.e.*, added, subtracted, multiplied or divided to achieve the final result. Since, all the observations in measurements do not have the same precision, it is natural that the final result cannot be more precise than the least precise measurement. The following two rules should be followed to obtain the proper number of significant figures in any calculation.

(1) The result of an addition or subtraction in the number having different precisions should be reported to the same number of decimal places as present in the number having the least number of decimal places. The rule is illustrated by the following examples :

(i)
33.3 ← (has only one decimal place)
3.11
\+ 0.313
36.723 ← (answer should be reported to one decimal place)

Answer = 36.7

(ii)
3.1421
0.241
\+ 0.09 ← (has 2 decimal places)
3.4731 ← (answer should be reported to 2 decimal places)

Answer = 3.47

(iii)
62.831 ← (has 3 decimal places)
− 24.5492
38.2818 ← (answer should be reported to 3 decimal places after rounding off)

Answer = 38.282

(2) The answer to a multiplication or division is rounded off to the same number of significant figures as possessed by the least precise term used in the calculation. The rule is illustrated by the following examples :

(i)
142.06
× 0.23 ← (two significant figures)
32.6738 ← (answer should have two significant figures)

Answer = 33

(ii)
51.028
× 1.31 ← (three significant figures)
66.84668

Answer = 66.8

(iii) $\dfrac{0.90}{4.26} = 0.2112676$

Answer = 0.21

Order of Magnitude

In scientific notation the numbers are expressed as, Number $= M \times 10^x$. Where M is a number lies between 1 and 10 and x is integer. Order of magnitude of quantity is the power of 10 required to represent the quantity. For determining this power, the value of the quantity has to be rounded off. While rounding off, we ignore the last digit which is less than 5. If the last digit is 5 or more than five, the preceding digit is increased by one. For example,

(1) Speed of light in vacuum

$= 3 \times 10^8 ms^{-1} \approx 10^8 m/s$ (ignoring 3 < 5)

(2) Mass of electron $= 9.1 \times 10^{-31} kg \approx 10^{-30} kg$ (as 9.1 > 5).

Errors of Measurement

The measuring process is essentially a process of comparison. Inspite of our best efforts, the measured value of a quantity is always somewhat different from its actual value, or true value. 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 $a_1, a_2, a_3, \ldots a_n$. The arithmetic mean of these value is

$$a_m = \frac{a_1 + a_2 + \ldots\ldots + a_n}{n}$$

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

$$\overline{\Delta a} = \frac{|\Delta a_1| + |\Delta a_2| + \ldots.. + |\Delta a_n|}{n}$$

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

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

(4) **Percentage error :** When the relative/fractional error is expressed in percentage, we call it percentage error. Thus

$$\text{Percentage error} = \frac{\overline{\Delta a}}{a_m} \times 100\%$$

Propagation of Errors

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

Let Δa = absolute error in measurement of a

Δb = absolute error in measurement of b

Δx = absolute error in calculation of x *i.e.* sum of a and b.

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

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

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

Let Δa = absolute error in measurement of a,

Δb = absolute error in measurement of b

Δx = absolute error in calculation of x *i.e.* difference of a and b.

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

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

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

Suppose $x = a \times b$

Let Δa = absolute error in measurement of a,

Δb = absolute error in measurement of b

Δx = absolute error in calculation of x *i.e.* product of a and b.

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

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 Δa = absolute error in measurement of a,

Δb = absolute error in measurement of b

Δx = absolute error in calculation of x *i.e.* division of a and b.

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

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 Δa = absolute error in measurement of a,

Δb = absolute error in measurement of b

Δx = absolute error in calculation of x

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

Percentage error in the value of x

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

Tips & Tricks

✍ The standard of Weight and Measures Act was passed in India in 1976. It recommended the use of SI in all fields of science, technology, trade and industry.

✍ The dimensions of many physical quantities, especially those in heat, thermodynamics, electricity and magnetism in terms of mass, length and time alone become irrational. Therefore, SI is adopted which uses 7 basic units.

✍ The dimensions of a physical quantity are the powers to which basic units (not fundamental units alone) should be raised to represent the derived unit of that physical quantity.

- The dimensional formula is very helpful in writing the unit of a physical quantity in terms of the basic units.
- The dimensions of a physical quantity do not depend on the system of units.
- A physical quantity that does not have any unit must be dimensionless.
- The pure numbers are dimensionless.
- Generally, the symbols of those basic units, whose dimension (power) in the dimensional formula is zero, are omitted from the dimensional formula.
- It is wrong to say that the dimensions of force are MLT^{-2}. On the other hand we should say that the dimensional formula for force is MLT^{-2} and that the dimensions of force are 1 in mass, 1 in length and –2 in time.
- Physical quantities defined as the ratio of two similar quantities are dimensionless.
- The physical relation involving logarithm, exponential, trigonometric ratios, numerical factors etc. cannot be derived by the method of dimensional analysis.
- Physical relations involving addition or subtraction sign cannot be derived by the method of dimensional analysis.
- If units or dimensions of two physical quantities are same, these need not represent the same physical characteristics. For example torque and work have the same units and dimensions but their physical characteristics are different.
- The standard units must not change with space and time. That is why atomic standard of length and time have been defined. Attempts are being made to define the atomic standard for mass as well.
- The unit of time, the second, was initially defined in terms of the rotation of the earth around the sun as well as that about its own axis. This time standard is subjected to variation with time. Therefore, the atomic standard of time has been defined.
- Any repetitive phenomenon, such as an oscillating pendulum, spinning of earth about its axis, etc can be used to measure time.
- The product of numerical value of the physical quantity (n) and its unit (U) remains constant.

That is : nU = constant or $n_1U_1 = n_2U_2$.

- The product of numerical value (n) and unit (U) of a physical quantity is called magnitude of the physical quantity.

Thus : Magnitude = nU

- Poiseuille (unit of viscosity) = pascal (unit of pressure) × second. That is : Pl : Pa- s.
- The unit of power of lens (dioptre) gives the ability of the lens to converge or diverge the rays refracted through it.
- The order of magnitude of a quantity means its value (in suitable power of 10) nearest to the actual value of the quantity.
- Angle is exceptional physical quantity, which though is a ratio of two similar physical quantities (angle = arc / radius) but still requires a unit (degrees or radians) to specify it along with its numerical value.
- Solid angle subtended at a point inside the closed surface is 4π steradian.
- A measurement of a physical quantity is said to be accurate if the systematic error in its measurement is relatively very low. On the other hand, the measurement of a physical quantity is said to be precise if the random error is small.
- A measurement is most accurate if its observed value is very close to the true value.
- Errors are always additive in nature.
- For greater accuracy, the quantity with higher power should have least error.
- The absolute error in each measurement is equal to the least count of the measuring instrument.
- Percentage error = relative error × 100.
- The unit and dimensions of the absolute error are same as that of quantity itself.
- Absolute error is not dimensionless quantity.
- Relative error is dimensionless quantity.
- Least Count = $\dfrac{\text{value of 1 part on main scale}(s)}{\text{Number of parts on vernier scale}(n)}$
- Least count of vernier callipers

$$= \left\{\begin{matrix}\text{value of 1 part of} \\ \text{main scale}(s)\end{matrix}\right\} - \left\{\begin{matrix}\text{value of 1 part of} \\ \text{vernier scale}(v)\end{matrix}\right\}$$

$\Rightarrow$ Least count of vernier calliper = 1 MSD – 1 VSD

where MSD = Main Scale Division

VSD = Vernier Scale Division

- Least count of screw guaze = $\dfrac{\text{Pitch}(p)}{\text{No. of parts on circular scale}(n)}$
- Smaller the least count, higher is the accuracy of measurement.
- Larger the number of significant figures after the decimal in a measurement, higher is the accuracy of measurement.
- Significant figures do not change if we measure a physical quantity in different units.
- Significant figures retained after mathematical operation (like addition, subtraction, multiplication and division) should be equal to the minimum significant figures involved in any physical quantity in the given operation.
- Significant figures are the number of digits upto which we are sure about their accuracy.
- If a number is without a decimal and ends in one or more zeros, then all the zeros at the end of the number may not be significant. To make the number of significant figures clear, it is suggested that the number may be written in exponential form. For example 20300 may be expressed as 203.00×10^2, to suggest that all the zeros at the end of 20300 are significant.
- 1 *inch* = 2.54 *cm*

  1 *foot* = 12 *inches* = 30.48 *cm* = 0.3048 *m*

  1 *mile* = 5280 *ft* = 1.609 *km*
- 1 *yard* = 0.9144 *m*

- $1\ slug = 14.59\ kg$
- $1\ barn = 10^{-28}\ m^2$
- $1\ liter = 10^3\ cm^3 = 10^{-3}\ m^3$
- $1\ km/h = \dfrac{5}{18}\ m/s$

  $1\ m/s = 3.6\ km/h$
- $1\ g/cm^3 = 1000\ kg/m^3$
- $1\ atm. = 76\ cm$ of $Hg = 1.013 \times 10^5\ N/m^2$

  $1\ N/m^2 = Pa\ (Pascal)$
- When we add or subtract two measured quantities, the absolute error in the final result is equal to the sum of the absolute errors in the measured quantities.
- When we multiply or divide two measured quantities, the relative error in the final result is equal to the sum of the relative errors in the measured quantities.

Ordinary Thinking

Objective Questions

Units

1. Light year is a unit of [MP PMT 1989; CPMT 1991; AFMC 1991,2005]
   (a) Time (b) Mass
   (c) Distance (d) Energy

2. The magnitude of any physical quantity
   (a) Depends on the method of measurement
   (b) Does not depend on the method of measurement
   (c) Is more in SI system than in CGS system
   (d) Directly proportional to the fundamental units of mass, length and time

3. Which of the following is not equal to *watt* [SCRA 1991; CPMT 1990]
   (a) *Joule/second* (b) *Ampere* × *volt*
   (c) $(Ampere)^2 \times ohm$ (d) *Ampere/volt*

4. Newton–*second* is the unit of [CPMT 1984, 85; MP PMT 1984]
   (a) Velocity (b) Angular momentum
   (c) Momentum (d) Energy

5. Which of the following is not represented in correct unit [NCERT 1984; MNR 1995]
   (a) $\frac{\text{Stress}}{\text{Strain}} = N/m^2$ (b) Surface tension $= N/m$
   (c) Energy $= kg\text{-}m/\sec$ (d) Pressure $= N/m^2$

6. One *second* is equal to [MNR 1986]
   (a) 1650763.73 time periods of Kr clock
   (b) 652189.63 time periods of Kr clock
   (c) 1650763.73 time periods of Cs clock
   (d) 9192631770 time periods of Cs clock

7. One nanometre is equal to [SCRA 1986; MNR 1986]
   (a) $10^9 mm$ (b) $10^{-6} cm$
   (c) $10^{-7} cm$ (d) $10^{-9} cm$

8. A *micron* is related to centimetre as
   (a) $1\, micron = 10^{-8} cm$ (b) $1\, micron = 10^{-6} cm$
   (c) $1\, micron = 10^{-5} cm$ (d) $1\, micron = 10^{-4}\, cm$

9. The unit of power is [CPMT 1985]
   (a) *Joule*
   (b) *Joule* per *second* only
   (c) *Joule* per *second* and *watt* both
   (d) Only *watt*

10. A suitable unit for gravitational constant is [MNR 1988]
    (a) $kg\text{-}m\sec^{-1}$ (b) $N\ m^{-1}\sec$
    (c) $N\ m^2\ kg^{-2}$ (d) $kg\, m\sec^{-1}$

11. SI unit of pressure is [EAMCET 1980; DPMT 1984; CBSE PMT 1988; NCERT 1976; AFMC 1991; USSR MEE 1991]
    (a) *Pascal* (b) $Dynes/cm^2$
    (c) cm of Hg (d) *Atmosphere*

12. The unit of angular acceleration in the SI system is [SCRA 1980; EAMCET 1981]
    (a) $N\, kg^{-1}$ (b) $m\, s^{-2}$
    (c) $rad\, s^{-2}$ (d) $m\, kg^{-1} K$

13. The unit of Stefan's constant σ is [AFMC 1986; MP PET 1992; MP PMT 1992; CBSE PMT 2002]
    (a) $W\, m^{-2}\, K^{-1}$ (b) $W\, m^2\, K^{-4}$
    (c) $W\, m^{-2}\, K^{-4}$ (d) $W\, m^{-2}\, K^4$

14. Which of the following is not a unit of energy [AIIMS 1985]
    (a) $W\text{-}s$ (b) $kg\text{-}m/\sec$
    (c) $N\text{-}m$ (d) *Joule*

15. In $S = a + bt + ct^2$. S is measured in metres and t in *seconds*. The unit of c is [MP PMT 1993]
    (a) None (b) m
    (c) ms^{-1} (d) ms^{-2}

16. *Joule-second* is the unit of [CPMT 1990; CBSE PMT 1993; BVP 2003]
    (a) Work (b) Momentum
    (c) Pressure (d) Angular momentum

17. Unit of energy in SI system is [CPMT 1971; NCERT 1976]
    (a) *Erg* (b) *Calorie*
    (c) *Joule* (d) Electron *volt*

18. A cube has numerically equal volume and surface area. The volume of such a cube is [CPMT 1971, 74]
    (a) 216 *units* (b) 1000 *units*
    (c) 2000 *units* (d) 3000 *units*

19. Wavelength of ray of light is $0.00006\, m$. It is equal to [CPMT 1977]
    (a) $6\ microns$ (b) $60\ microns$
    (c) $600\ microns$ (d) $0.6\ microns$

20. Electron *volt* is a unit of [MP PMT 1993]
    (a) Charge (b) Potential difference
    (c) Momentum (d) Energy

21. Temperature can be expressed as a derived quantity in terms of any of the following [MP PET 1993; UPSEAT 2001]
    (a) Length and mass
    (b) Mass and time
    (c) Length, mass and time
    (d) None of these

22. Unit of power is [NCERT 1972; CPMT 1971; DCE 1999]

(a) *Kilowatt* (b) *Kilowatt-hour*
(c) *Dyne* (d) *Joule*

23. Density of wood is $0.5 gm/cc$ in the CGS system of units. The corresponding value in MKS units is [CPMT 1983; NCERT 1973; JIPMER 1993]
(a) 500 (b) 5
(c) 0.5 (d) 5000

24. Unit of energy is [NCERT 1974; CPMT 1975]
(a) $J/\sec$ (b) $Watt-day$
(c) $Kilowatt$ (d) $gm\text{-}cm/\sec^2$

25. Which is the correct unit for measuring nuclear radii
(a) *Micron* (b) *Millimetre*
(c) *Angstrom* (d) *Fermi*

26. One Mach number is equal to
(a) Velocity of light
(b) Velocity of sound $(332\ m/\sec)$
(c) $1\ km/\sec$
(d) $1\ m/\sec$

27. The unit for nuclear dose given to a patient is
(a) *Fermi* (b) Rutherford
(c) Curie (d) Roentgen

28. *Volt/metre* is the unit of [AFMC 1991; CPMT 1984]
(a) Potential (b) Work
(c) Force (d) Electric intensity

29. $Newton/metre^2$ is the unit of [CPMT 1985; ISM Dhanbad 1994; AFMC 1995]
(a) Energy (b) Momentum
(c) Force (d) Pressure

30. The unit of surface tension in SI system is [MP PMT 1984; AFMC 1986; CPMT 1985, 87; CBSE PMT 1993; KCET 1999; DCE 2000, 01]
(a) $Dyne/cm^2$ (b) $Newton/m$
(c) $Dyne/cm$ (d) $Newton/m^2$

31. The unit of reduction factor of tangent galvanometer is [CPMT 1987; AFMC 2004]
(a) *Ampere* (b) *Gauss*
(c) *Radian* (d) None of these

32. The unit of self inductance of a coil is [MP PMT 1983, 92; SCRA 1986; CBSE PMT 1993; CPMT 1984, 85, 87]
(a) *Farad* (b) *Henry*
(c) *Weber* (d) *Tesla*

33. *Henry/ohm* can be expressed in [CPMT 1987]
(a) *Second* (b) *Coulomb*
(c) *Mho* (d) *Metre*

34. The SI unit of momentum is [SCRA 1986, 89; CPMT 1987]
(a) $\frac{kg}{m}$ (b) $\frac{kg.m}{\sec}$
(c) $\frac{kg.m^2}{\sec}$ (d) $kg \times Newton$

35. The velocity of a particle depends upon as $v = a + bt + ct^2$; if the velocity is in $m/\sec$, the unit of a will be [CPMT 1990]
(a) $m/\sec$ (b) $m/\sec^2$
(c) $m^2/\sec$ (b) $m/\sec^3$

36. One million electron *volt* $(1\ MeV)$ is equal to [JIPMER 1993, 97]
(a) $10^5\ eV$ (b) $10^6\ eV$
(c) $10^4\ eV$ (d) $10^7\ eV$

37. $Erg - m^{-1}$ can be the unit of measure for [DCE 1993]
(a) Force (b) Momentum
(c) Power (d) Acceleration

38. The unit of potential energy is [AFMC 1991]
(a) $g(cm/\sec^2)$ (b) $g(cm/\sec)^2$
(c) $g(cm^2/\sec)$ (d) $g(cm/\sec)$

39. Which of the following represents a *volt* [CPMT 1990; AFMC 1991]
(a) *Joule/second* (b) *Watt/Ampere*
(c) *Watt/Coulomb* (d) *Coulomb/Joule*

40. $Kilowatt-hour$ is a unit of [NCERT 1975; AFMC 1991]
(a) Electrical charge (b) Energy
(c) Power (d) Force

41. What is the SI unit of permeability [CBSE PMT 1993]
(a) *Henry* per *metre*
(b) Tesla *metre* per *ampere*
(c) *Weber* per *ampere metre*
(d) All the above units are correct

42. In which of the following systems of unit, $Weber$ is the unit of magnetic flux [SCRA 1991; CBSE PMT 1993; DPMT 2005]
(a) CGS (b) MKS
(c) SI (d) None of these

43. Tesla is a unit for measuring [CBSE PMT 1993]
(a) Magnetic moment (b) Magnetic induction
(c) Magnetic intensity (d) Magnetic pole strength

44. If the unit of length and force be increased four times, then the unit of energy is [Kerala PMT 2005]
(a) Increased 4 times (b) Increased 8 times
(c) Increased 16 times (d) Decreased 16 times

45. Oersted is a unit of [SCRA 1989]
(a) Dip (b) Magnetic intensity
(c) Magnetic moment (d) Pole strength

46. $Ampere - hour$ is a unit of [SCRA 1980, 89; ISM Dhanbad 1994]
(a) Quantity of electricity
(b) Strength of electric current
(c) Power
(d) Energy

47. The unit of specific resistance is [SCRA 1989; MP PET 1984; CPMT 1975]
(a) Ohm/cm^2 (b) Ohm/cm
(c) $Ohm\text{–}cm$ (d) $(Ohm\text{–}cm)^{-1}$

48. The binding energy of a nucleon in a nucleus is of the order of a few [SCRA 1979]

(a) eV (b) $Ergs$
(c) MeV (d) $Volts$

49. $Parsec$ is a unit of [SCRA 1986; BVP 2003; AIIMS 2005]
(a) Distance (b) Velocity
(c) Time (d) Angle

50. If u_1 and u_2 are the units selected in two systems of measurement and n_1 and n_2 their numerical values, then [SCRA 1986]
(a) $n_1u_1 = n_2u_2$ (b) $n_1u_1 + n_2u_2 = 0$
(c) $n_1n_2 = u_1u_2$ (d) $(n_1 + u_1) = (n_2 + u_2)$

51. $1\,eV$ is [SCRA 1986]
(a) Same as one *joule* (b) $1.6 \times 10^{-19}\,J$
(c) $1V$ (d) $1.6 \times 10^{-19}\,C$

52. $1kWh =$ [AFMC 1986; SCRA 1986, 91]
(a) $1000W$ (b) $36 \times 10^5\,J$
(c) $1000J$ (d) $3600\,J$

53. Universal time is based on [SCRA 1989]
(a) Rotation of the earth on its axis
(b) Earth's orbital motion around the earth
(c) Vibrations of cesium atom
(d) Oscillations of quartz crystal

54. The nuclear cross-section is measured in barn, it is equal to
(a) $10^{-20}\,m^2$ (b) $10^{-30}\,m^2$
(c) $10^{-28}\,m^2$ (d) $10^{-14}\,m^2$

55. Unit of moment of inertia in MKS system [MP PMT 1984]
(a) $kg \times cm^2$ (b) kg/cm^2
(c) $kg \times m^2$ (d) $Joule \times m$

56. Unit of stress is [MP PMT 1984]
(a) N/m (b) $N\text{–}m$
(c) N/m^2 (d) $N\text{–}m^2$

57. Unit of Stefan's constant is [MP PMT 1989]
(a) $J\,s^{-1}$ (b) $J\,m^{-2}s^{-1}K^{-4}$
(c) $J\,m^{-2}$ (d) $J\,s$

58. Unit of magnetic moment is [MP PET 1989]
(a) $Ampere\text{–}metre^2$ (b) $Ampere\text{–}metre$
(c) $Weber\text{–}metre^2$ (c) $Weber/metre$

59. Curie is a unit of [CBSE PMT 1992; CPMT 1992]
(a) Energy of γ-rays (b) Half life
(c) Radioactivity (d) Intensity of γ-rays

60. Hertz is the unit for [MNR 1983; SCRA 1983; RPMT 1999]
(a) Frequency (b) Force
(c) Electric charge (d) Magnetic flux

61. One pico *Farad* is equal to
(a) $10^{-24}\,F$ (b) $10^{-18}\,F$
(c) $10^{-12}\,F$ (d) $10^{-6}\,F$

62. In SI, *Henry* is the unit of [MP PET 1984; CBSE PMT 1993; DPMT 1984]
(a) Self inductance (b) Mutual inductance
(c) (a) and (b) both (d) None of the above

63. The unit of $e.m.f.$ is [CPMT 1986; AFMC 1986]
(a) *Joule* (b) *Joule-Coulomb*
(c) *Volt–Coulomb* (d) *Joule/Coulomb*

64. Which of the following is not the unit of time [CPMT 1991; NCERT 1990; DPMT 1987; AFMC 1996]
(a) Micro *second* (b) Leap year
(c) Lunar months (d) Parallactic *second*
(e) Solar day

65. Unit of self inductance is [MP PET 1982]
(a) $\dfrac{Newton\text{ - }second}{Coulomb \times Ampere}$ (b) $\dfrac{Joule/Coulomb \times Second}{Ampere}$
(c) $\dfrac{Volt \times metre}{Coulomb}$ (d) $\dfrac{Newton \times metre}{Ampere}$

66. To determine the Young's modulus of a wire, the formula is $Y = \dfrac{F}{A} \times \dfrac{L}{\Delta L}$; where L = length, A = area of cross-section of the wire, ΔL = change in length of the wire when stretched with a force F. The conversion factor to change it from CGS to MKS system is
(a) 1 (b) 10
(c) 0.1 (d) 0.01

67. Young's modulus of a material has the same units as [MP PMT 1994]
(a) Pressure (b) Strain
(c) Compressibility (d) Force

68. One yard in SI units is equal [MP PMT 1995]
(a) 1.9144 $metre$ (b) 0.9144 $metre$
(c) 0.09144 $kilometre$ (d) 1.0936 $kilometre$

69. Which of the following is smallest unit [AFMC 1996]
(a) *Millimetre* (b) *Angstrom*
(c) *Fermi* (d) *Metre*

70. Which one of the following pairs of quantities and their units is a proper match
(a) Electric field – $Coulomb\,/\,m$
(b) Magnetic flux – $Weber$
(c) Power – *Farad*
(d) Capacitance – *Henry*

71. The units of modulus of rigidity are [MP PMT 1997]
(a) $N\text{–}m$ (b) N/m
(c) $N\text{–}m^2$ (d) N/m^2

72. The unit of absolute permittivity is [CMEET Bihar 1995]
(a) Fm (*Farad*-meter) (b) Fm^{-1} (*Farad*/meter)
(c) Fm^{-2} (*Farad*/ $metre^2$) (d) F (*Farad*)
(e) None of these

73. Match List-I with List-II and select the correct answer using the codes given below the lists [SCRA 1994]

List-I	List-II
I. *Joule*	A. *Henry* × *Amp*/*sec*
II. *Watt*	B. *Farad* × *Volt*
III. *Volt*	C. *Coulomb* × *Volt*

IV. *Coulomb* D. *Oersted* $\times$ *cm*

E. *Amp* $\times$ *Gauss*

F. $Amp^2 \times Ohm$

Codes:

(a) $I-A, II-F, III-E, IV-D$

(b) $I-C, II-F, III-A, IV-B$

(c) $I-C, II-F, III-A, IV-E$

(d) $I-B, II-F, III-A, IV-C$

74. Which relation is wrong [RPMT 1997]

(a) 1 *Calorie* = 4.18 *Joules*

(b) $1 Å = 10^{-10} m$

(c) $1\ MeV = 1.6 \times 10^{-13}\ Joules$

(d) $1\ Newton = 10^{-5}\ Dynes$

75. If $x = at + bt^2$, where x is the distance travelled by the body in kilometres while t is the time in seconds, then the units of b are

(a) km/s (b) $km\text{–}s$

(c) km/s^2 (d) $km\text{–}s^2$

76. The equation $\left(P + \frac{a}{V^2}\right)(V - b)$ constant. The units of a are

(a) $Dyne \times cm^5$ (b) $Dyne \times cm^4$

(c) $Dyne/cm^3$ (d) $Dyne/cm^2$

77. Which of the following quantity is expressed as force per unit area

(a) Work (b) Pressure

(c) Volume (d) Area

78. Match List-I with List-II and select the correct answer by using the codes given below the lists [NDA 1995]

List-I	List-II
(a) Distance between earth and stars	1. Microns
(b) Inter-atomic distance in a solid	2. Angstroms
(c) Size of the nucleus	3. Light years
(d) Wavelength of infrared laser	4. *Fermi*
	5. Kilometres

Codes

	a	b	c	d		a	b	c	d
(a)	5	4	2	1	(b)	3	2	4	1
(c)	5	2	4	3	(d)	3	4	1	2

79. Unit of impulse is [CPMT 1997]

(a) Newton (b) $kg\text{–}m$

(c) $kg\text{–}m/s$ (d) *Joule*

80. Which is not a unit of electric field [UPSEAT 1999]

(a) NC^{-1} (b) Vm^{-1}

(c) JC^{-1} (d) $JC^{-1}m^{-1}$

81. The correct value of $0^o C$ on the Kelvin scale is [UPSEAT 2000]

(a) $273.15 K$ (b) $272.85 K$

(c) $273 K$ (d) $273.2 K$

82. 'Torr' is the unit of [RPMT 1999, 2000]

(a) Pressure (b) Volume

(c) Density (d) Flux

83. Which of the following is a derived unit [BHU 2000]

(a) Unit of mass (b) Unit of length

(c) Unit of time (d) Unit of volume

84. *Dyne/cm* is not a unit of [RPET 2000]

(a) Pressure (b) Stress

(c) Strain (d) Young's modulus

85. The units of angular momentum are [MP PMT 2000]

(a) $kg\text{–}m^2/s^2$ (b) *Joule–s*

(c) *Joule/s* (d) $kg\text{–}m\text{–}s^2$

86. Which of the following is not the unit of energy [MP PET 2000]

(a) *Calorie* (b) *Joule*

(c) Electron *volt* (d) *Watt*

[CBSE PMT 1993]

87. Which of the following is not a unit of time [UPSEAT 2001]

(a) *Leap year* (b) *Micro second*

(c) *Lunar month* (d) *Light year*

88. The S.I. unit of gravitational potential is [AFMC 2001]

(a) J [MNR 1995; AFMC 1995] (b) $J\text{-}kg^{-1}$

(c) $J\text{-}kg$ (d) $J\text{-}kg^{-2}$

89. Which one of the following is not a unit of young's modulus [KCET 2005]

(a) Nm [AFMC 1995] (b) Nm^{-2}

(c) $Dyne\ cm^{-2}$ (d) Mega Pascal

90. In C.G.S. system the magnitutde of the force is 100 *dynes*. In another system where the fundamental physical quantities are kilogram, *metre* and minute, the magnitude of the force is

(a) 0.036 (b) 0.36

(c) 3.6 (d) 36

91. The unit of L/R is (where L = inductance and R = resistance)

(a) sec (b) sec^{-1}

(c) *Volt* (d) *Ampere*

92. Which is different from others by units [Orissa JEE 2002]

(a) Phase difference (b) Mechanical equivalent

(c) Loudness of sound (d) Poisson's ratio

93. Length cannot be measured by [AIIMS 2002]

(a) *Fermi* (b) Debye

(c) *Micron* (d) *Light year*

94. The value of Planck's constant is [CBSE PMT 2002]

(a) 6.63×10^{-34} *J-sec* (b) 6.63×10^{34} *J/sec*

(c) $6.63 \times 10^{-34}\ kg\text{-}m^2$ (d) $6.63 \times 10^{34}\ kg/sec$

95. A physical quantity is measured and its value is found to be nu where $n =$ numerical value and $u =$ unit. Then which of the following relations is true [RPET 2003]

(a) $n \propto u^2$ (b) $n \propto u$

(c) $n \propto \sqrt{u}$ (d) $n \propto \frac{1}{u}$

96. *Faraday* is the unit of [AFMC 2003]

(a) Charge (b) emf
(c) Mass (d) Energy

97. *Candela* is the unit of [UPSEAT 1999; CPMT 2003]
(a) Electric intensity (b) Luminous intensity
(c) Sound intensity (d) None of these

98. The unit of reactance is [MP PET 2003]
(a) *Ohm* (b) *Volt*
(c) *Mho* (d) *Newton*

99. The unit of Planck's constant is [RPMT 1999; MP PET 2003; Pb. PMT 2004]
(a) *Joule* (b) *Joule/s*
(c) *Joule/m* (d) *Joule-s*

100. Number of base SI units is [MP PET 2003]
(a) 4 (b) 7
(c) 3 (d) 5

101. SI unit of permittivity is [KCET 2004]
(a) $C^2m^2N^{-1}$ (b) $C^{-1}m^2N^{-2}$
(c) $C^2m^2N^2$ (d) $C^2m^{-2}N^{-1}$

102. Which does not has the same unit as others [Orissa PMT 2004]
(a) *Watt-sec* (b) *Kilowatt-hour*
(c) *eV* (d) *J-sec*

103. Unit of surface tension is [Orissa PMT 2004]
(a) Nm^{-1} (b) Nm^{-2}
(c) N^2m^{-1} (d) Nm^{-3}

104. Which of the following system of units is not based on units of mass, length and time alone [Kerala PMT 2004]
(a) SI (b) MKS
(c) FPS (d) CGS

105. The unit of the coefficient of viscosity in S.I. system is [J & K CET 2004]
(a) $m / kg\text{-}s$ (b) $m\text{-}s/kg^2$
(c) $kg/m\text{-}s^2$ (d) $kg/m\text{-}s$

106. The unit of Young's modulus is [Pb. PET 2001]
(a) Nm^2 (b) Nm^{-2}
(c) Nm (d) Nm^{-1}

107. One femtometer is equivalent to [DCE 2004]
(a) $10^{15}\ m$ (b) $10^{-15}\ m$
(c) $10^{-12}\ m$ (d) $10^{12}\ m$

108. How many wavelength of Kr^{86} are there in one *metre* [MNR 1985; UPSEAT 2000; Pb. PET 2004]
(a) 1553164.13 (b) 1650763.73
(c) 652189.63 (d) 2348123.73

109. Which of the following pairs is wrong [AFMC 2003]
(a) Pressure-Baromter
(b) Relative density-Pyrometer
(c) Temperature-Thermometer
(d) Earthquake-Seismograph

Dimensions

1. Select the pair whose dimensions are same
(a) Pressure and stress
(b) Stress and strain
(c) Pressure and force
(d) Power and force

2. Dimensional formula $ML^{-1}T^{-2}$ does not represent the physical quantity [Manipal MEE 1995]
(a) Young's modulus of elasticity
(b) Stress
(c) Strain
(d) Pressure

3. Dimensional formula ML^2T^{-3} represents [EAMCET 1981; MP PMT 1996, 2001]
(a) Force (b) Power
(c) Energy (d) Work

4. The dimensions of *calorie* are [CPMT 1985]
(a) ML^2T^{-2} (b) MLT^{-2}
(c) ML^2T^{-1} (d) ML^2T^{-3}

5. Whose dimensions is ML^2T^{-1} [CPMT 1989]
(a) Torque (b) Angular momentum
(c) Power (d) Work

6. If L and R are respectively the inductance and resistance, then the dimensions of $\frac{L}{R}$ will be [CPMT 1986; CBSE PMT 1988; Roorkee 1995; MP PET/PMT 1998; DCE 2002]
(a) $M^0L^0T^{-1}$
(b) M^0LT^0
(c) M^0L^0T
(d) Cannot be represented in terms of M, L and T

7. Which pair has the same dimensions [EAMCET 1982; CPMT 1984, 85; Pb. PET 2002; MP PET 1985]
(a) Work and power
(b) Density and relative density
(c) Momentum and impulse
(d) Stress and strain

8. If C and R represent capacitance and resistance respectively, then the dimensions of RC are [CPMT 1981, 85; CBSE PMT 1992, 95; Pb. PMT 1999]
(a) $M^0L^0T^2$ (b) M^0L^0T
(c) ML^{-1} (d) None of the above

9. Dimensions of one or more pairs are same. Identify the pairs
(a) Torque and work
(b) Angular momentum and work
(c) Energy and Young's modulus
(d) Light year and wavelength

10. Dimensional formula for latent heat is [MNR 1987; CPMT 1978, 86; IIT 1983, 89; RPET 2002]
(a) $M^0L^2T^{-2}$ (b) MLT^{-2}

(c) ML^2T^{-2} (d) ML^2T^{-1}

11. Dimensional formula for volume elasticity is
[MP PMT 1991, 2002; CPMT 1991; MNR 1986]
(a) $M^1L^{-2}T^{-2}$ (b) $M^1L^{-3}T^{-2}$
(c) $M^1L^2T^{-2}$ (d) $M^1L^{-1}T^{-2}$

12. The dimensions of universal gravitational constant are
[MP PMT 1984, 87, 97, 2000; CBSE PMT 1988, 92; 2004 MP PET 1984, 96, 99; MNR 1992; DPMT 1984; CPMT 1978, 84, 89, 90, 92, 96; AFMC 1999; NCERT 1975; DPET 1993; AIIMS 2000; RPET 2001; Pb. PMT 2002, 03; UPSEAT 1999; BCECE 2003, 05;]
(a) $M^{-2}L^2T^{-2}$ (b) $M^{-1}L^3T^{-2}$
(c) $ML^{-1}T^{-2}$ (d) ML^2T^{-2}

13. The dimensional formula of angular velocity is
[JIPMER 1993; AFMC 1996; AIIMS 1998]
(a) $M^0L^0T^{-1}$ (b) MLT^{-1}
(c) $M^0L^0T^1$ (d) ML^0T^{-2}

14. The dimensions of power are
[CPMT 1974, 75; SCRA 1989]
(a) $M^1L^2T^{-3}$ (b) $M^2L^1T^{-2}$
(c) $M^1L^2T^{-1}$ (d) $M^1L^1T^{-2}$

15. The dimensions of couple are [CPMT 1972; JIPMER 1993]
(a) ML^2T^{-2} (b) MLT^{-2}
(c) $ML^{-1}T^{-3}$ (d) $ML^{-2}T^{-2}$

16. Dimensional formula for angular momentum is
[CBSE PMT 1988, 92; EAMCET 1995; DPMT 1987; CMC Vellore 1982; CPMT 1973, 82, 86; MP PMT 1987; BHU 1995; IIT 1983; Pb. PET 2000]
(a) ML^2T^{-2} (b) ML^2T^{-1}
(c) MLT^{-1} (d) $M^0L^2T^{-2}$

17. The dimensional formula for impulse is
[EAMCET 1981; CBSE PMT 1991; CPMT 1978; AFMC 1998; BCECE 2003]
(a) MLT^{-2} (b) MLT^{-1}
(c) ML^2T^{-1} (d) M^2LT^{-1}

18. The dimensional formula for the modulus of rigidity is
[MNR 1984; IIT 1982; MP PET 2000]
(a) ML^2T^{-2} (b) $ML^{-1}T^{-3}$
(c) $ML^{-2}T^{-2}$ (d) $ML^{-1}T^{-2}$

19. The dimensional formula for $r.m.s.$ (root mean square) velocity is
(a) M^0LT^{-1} (b) $M^0L^0T^{-2}$
(c) $M^0L^0T^{-1}$ (d) MLT^{-3}

20. The dimensional formula for Planck's constant (h) is
[DPMT 1987; MP PMT 1983, 96; IIT 1985; MP PET 1995; AFMC 2003; RPMT 1999; Kerala PMT 2002]
(a) $ML^{-2}T^{-3}$ (b) ML^2T^{-2}
(c) ML^2T^{-1} (d) $ML^{-2}T^{-2}$

21. Out of the following, the only pair that does not have identical dimensions is [MP PET/PMT 1998; BHU 1997]
(a) Angular momentum and Planck's constant
(b) Moment of inertia and moment of a force
(c) Work and torque
(d) Impulse and momentum

22. The dimensional formula for impulse is same as the dimensional formula for
[CPMT 1982, 83; CBSE PMT 1993; UPSEAT 2001]
(a) Momentum
(b) Force
(c) Rate of change of momentum
(d) Torque

23. Which of the following is dimensionally correct
(a) Pressure = Energy per unit area
(b) Pressure = Energy per unit volume
(c) Pressure = Force per unit volume
(d) Pressure = Momentum per unit volume per unit time

24. Planck's constant has the dimensions (unit) of
[CPMT 1983, 84, 85, 90, 91; AIIMS 1985; MP PMT 1987; EAMCET 1990; RPMT 1999; CBSE PMT 2001; MP PET 2002; KCET 2004]
(a) Energy (b) Linear momentum
(c) Work (d) Angular momentum

25. The equation of state of some gases can be expressed as $\left(P+\frac{a}{V^2}\right)(V-b)=RT$. Here P is the pressure, V is the volume, T is the absolute temperature and a, b, R are constants. The dimensions of 'a' are
[CBSE PMT 1991, 96; NCERT 1984; MP PET 1992; CPMT 1974, 79, 87, 97; MP PMT 1992, 94; MNR 1995; AFMC 1995]
(a) ML^5T^{-2} (b) $ML^{-1}T^{-2}$
(c) $M^0L^3T^0$ (d) $M^0L^6T^0$

26. If V denotes the potential difference across the plates of a capacitor of capacitance C, the dimensions of CV^2 are
[CPMT 1982]
(a) Not expressible in MLT (b) MLT^{-2}
(c) M^2LT^{-1} (d) ML^2T^{-2}

27. If L denotes the inductance of an inductor through which a current i is flowing, the dimensions of Li^2 are
[CPMT 1982, 85, 87]
(a) ML^2T^{-2} (b) Not expressible in MLT
(c) MLT^{-2} (d) $M^2L^2T^{-2}$

28. Of the following quantities, which one has dimensions different from the remaining three
[AIIMS 1987; CBSE PMT 1993]
(a) Energy per unit volume
(b) Force per unit area
(c) Product of voltage and charge per unit volume
(d) Angular momentum per unit mass

29. A spherical body of mass m and radius r is allowed to fall in a medium of viscosity η. The time in which the velocity of the body

increases from zero to 0.63 times the terminal velocity (v) is called time constant (τ). Dimensionally τ can be represented by

(a) $\frac{mr^2}{6\pi\eta}$ (b) $\sqrt{\left(\frac{6\pi mr\eta}{g^2}\right)}$

(c) $\frac{m}{6\pi\eta rv}$ (d) None of the above

30. The frequency of vibration f of a mass m suspended from a spring of spring constant K is given by a relation of this type $f = Cm^x K^y$; where C is a dimensionless quantity. The value of x and y are [CBSE PMT 1990]

(a) $x = \frac{1}{2}, y = \frac{1}{2}$ (b) $x = -\frac{1}{2}, y = -\frac{1}{2}$

(c) $x = \frac{1}{2}, y = -\frac{1}{2}$ (d) $x = -\frac{1}{2}, y = \frac{1}{2}$

31. The quantities A and B are related by the relation, $m = A/B$, where m is the linear density and A is the force. The dimensions of B are of

(a) Pressure (b) Work

(c) Latent heat (d) None of the above

32. The velocity of water waves v may depend upon their wavelength λ, the density of water ρ and the acceleration due to gravity g. The method of dimensions gives the relation between these quantities as [NCERT 1979; CET 1992; MP PET 2001; UPSEAT 2000]

(a) $v^2 \propto \lambda g^{-1} \rho^{-1}$ (b) $v^2 \propto g\lambda\rho$

(c) $v^2 \propto g\lambda$ (d) $v^2 \propto g^{-1}\lambda^{-3}$

33. The dimensions of *Farad* are [MP PET 1993]

(a) $M^{-1}L^{-2}T^2Q^2$ (b) $M^{-1}L^{-2}TQ$

(c) $M^{-1}L^{-2}T^{-2}Q$ (d) $M^{-1}L^{-2}TQ^2$

34. The dimensions of resistivity in terms of M, L, T and Q where Q stands for the dimensions of charge, is [MP PET 1993]

(a) $ML^3T^{-1}Q^{-2}$ (b) $ML^3T^{-2}Q^{-1}$

(c) $ML^2T^{-1}Q^{-1}$ (d) $MLT^{-1}Q^{-1}$

35. The equation of a wave is given by

$$Y = A\sin\omega\left(\frac{x}{v} - k\right)$$

where ω is the angular velocity and v is the linear velocity. The dimension of k is [MP PMT 1993]

(a) LT (b) T

(c) T^{-1} (d) T^2

36. The dimensions of coefficient of thermal conductivity is [MP PMT 1993]

(a) $ML^2T^{-2}K^{-1}$ (b) $MLT^{-3}K^{-1}$

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

37. Dimensional formula of stress is [AIIMS 1987]

(a) M^0LT^{-2} (b) $M^0L^{-1}T^{-2}$

(c) $ML^{-1}T^{-2}$ (d) ML^2T^{-2}

38. Dimensional formula of velocity of sound is

(a) M^0LT^{-2} (b) LT^0

(c) M^0LT^{-1} (d) $M^0L^{-1}T^{-1}$

39. Dimensional formula of capacitance is [CPMT 1978; MP PMT 1979; IIT 1983]

(a) $M^{-1}L^{-2}T^4A^2$ (b) $ML^2T^4A^{-2}$

(c) $MLT^{-4}A^2$ (d) $M^{-1}L^{-2}T^{-4}A^{-2}$

40. MLT^{-1} represents the dimensional formula of [CPMT 1975]

(a) Power (b) Momentum

(c) Force (d) Couple

41. Dimensional formula of heat energy is [CPMT 1976, 81, 86, 91]

(a) ML^2T^{-2} (b) MLT^{-1}

(c) $M^0L^0T^{-2}$ (d) None of these

42. If C and L denote capacitance and inductance respectively, then the dimensions of LC are [CPMT 1981; MP PET 1997]

(a) $M^0L^0T^0$ (b) $M^0L^0T^2$

(c) $M^2L^0T^2$ (d) MLT^2

43. Which of the following quantities has the same dimensions as that of energy [AFMC 1991; CPMT 1976; DPMT 2001]

(a) Power (b) Force

(c) Momentum (d) Work

44. The dimensions of "time constant" $\frac{L}{R}$ during growth and decay of current in all inductive circuit is same as that of [MP PET 1993; EAMCET 1994]

(a) Constant (b) Resistance

(c) Current (d) Time

45. The period of a body under SHM *i.e.* presented by $T = P^aD^bS^c$; where P is pressure, D is density and S is surface tension. The value of a, b and c are [CPMT 1981]

(a) $-\frac{3}{2}, \frac{1}{2}, 1$ (b) $-1, -2, 3$

(c) $\frac{1}{2}, -\frac{3}{2}, -\frac{1}{2}$ (d) $1, 2, \frac{1}{3}$

46. Which of the following pairs of physical quantities has the same dimensions [CPMT 1978; NCERT 1987]

(a) Work and power (b) Momentum and energy

(c) Force and power (d) Work and energy

47. The velocity of a freely falling body changes as g^ph^q where g is acceleration due to gravity and h is the height. The values of p and q are [NCERT 1983; EAMCET 1994]

(a) $1, \frac{1}{2}$ (b) $\frac{1}{2}, \frac{1}{2}$

(c) $\frac{1}{2}, 1$ (d) $1, 1$

48. Which one of the following does not have the same dimensions
(a) Work and energy
(b) Angle and strain
(c) Relative density and refractive index
(d) Planck constant and energy

49. Dimensions of frequency are [CPMT 1988]
(a) $M^0L^{-1}T^0$ (b) $M^0L^0T^{-1}$
(c) M^0L^0T (d) MT^{-2}

50. Which one has the dimensions different from the remaining three
(a) Power (b) Work
(c) Torque (d) Energy

51. A small steel ball of radius r is allowed to fall under gravity through a column of a viscous liquid of coefficient of viscosity η. After some time the velocity of the ball attains a constant value known as terminal velocity v_T. The terminal velocity depends on (i) the mass of the ball m, (ii) η, (iii) r and (iv) acceleration due to gravity g. Which of the following relations is dimensionally correct
[CPMT 1992; CBSE PMT 1992; NCERT 1983; MP PMT 2001]
(a) $v_T \propto \frac{mg}{\eta r}$ (b) $v_T \propto \frac{\eta r}{mg}$
(c) $v_T \propto \eta rmg$ (d) $v_T \propto \frac{mgr}{\eta}$

52. The quantity $X = \frac{\varepsilon_0 LV}{t}$: ε_0 is the permittivity of free space, L is length, V is potential difference and t is time. The dimensions of X are same as that of [IIT 2001]
(a) Resistance (b) Charge
(c) Voltage (d) Current

53. μ_0 and ε_0 denote the permeability and permittivity of free space, the dimensions of $\mu_0\varepsilon_0$ are
(a) LT^{-1} (b) $L^{-2}T^2$
(c) $M^{-1}L^{-3}Q^2T^2$ (d) $M^{-1}L^{-3}I^2T^2$

54. The expression $[ML^2T^{-2}]$ represents [JIPMER 1993, 97]
(a) Pressure (b) Kinetic energy
(c) Momentum (d) Power

55. The dimensions of physical quantity X in the equation Force $= \frac{X}{\text{Density}}$ is given by [DCE 1993]
(a) $M^1L^4T^{-2}$ (b) $M^2L^{-2}T^{-1}$
(c) $M^2L^{-2}T^{-2}$ (d) $M^1L^{-2}T^{-1}$

56. The dimensions of CV^2 matches with the dimensions of [DCE 1993]
(a) L^2I (b) L^2I^2
(c) LI^2 (d) $\frac{1}{LI}$

57. The Martians use [CPMT 1985] force (F), acceleration (A) and time (T) as their fundamental physical quantities. The dimensions of length on Martians system are [DCE 1993]
(a) FT^2 (b) $F^{-1}T^2$
(c) $F^{-1}A^2T^{-1}$ (d) AT^2

58. The dimension of $\frac{1}{\sqrt{\varepsilon_0\mu_0}}$ is that of [SCRA 1986]
(a) Velocity (b) Time
(c) Capacitance [CBSE PMT 1988] (d) Distance

59. An athletic coach told his team that muscle times speed equals power. What dimensions does he view for muscle
(a) MLT^{-2} (b) ML^2T^{-2}
(c) MLT^2 (d) L

60. The foundations of dimensional analysis were laid down by
(a) Gallileo (b) Newton
(c) Fourier (d) Joule

61. The dimensional formula of wave number is
(a) $M^0L^0T^{-1}$ (b) $M^0L^{-1}T^0$
(c) $M^{-1}L^{-1}T^0$ (d) $M^0L^0T^0$

62. The dimensions of stress are equal to [MP PET 1991, 2003]
(a) Force (b) Pressure
(c) Work (d) $\frac{1}{\text{Pressure}}$

63. The dimensions of pressure are [CPMT 1977; MP PMT 1994]
(a) MLT^{-2} (b) $ML^{-2}T^2$
(c) $ML^{-1}T^{-2}$ (d) MLT^2

64. Dimensions of permeability are [CBSE PMT 1991; AIIMS 2003]
(a) $A^{-2}M^1L^1T^{-2}$ (b) MLT^{-2}
(c) ML^0T^{-1} (d) $A^{-1}MLT^2$

65. Dimensional formula of magnetic flux is [DCE 1993; IIT 1982; CBSE PMT 1989, 99; DPMT 2001; Kerala PMT 2005]
(a) $ML^2T^{-2}A^{-1}$ (b) $ML^0T^{-2}A^{-2}$
(c) $M^0L^{-2}T^{-2}A^{-3}$ (d) $ML^2T^{-2}A^3$

66. If P represents radiation pressure, c represents speed of light and Q represents radiation energy striking a unit area per *second*, then non-zero integers x, y and z such that $P^xQ^yc^z$ is dimensionless, are [AFMC 1991; CBSE PMT 1992; CPMT 1981, 92; MP PMT 1992]
(a) $x = 1,\ y = 1,\ z = -1$
(b) $x = 1, y = -1, z = 1$
(c) $x = -1, y = 1, z = 1$
(d) $x = 1, y = 1, z = 1$

67. Inductance L can be dimensionally represented as [CBSE PMT 1989, 92; IIT 1983; CPMT 1992; DPMT 1999; KCET 2004; J&K CET 2005]

(a) $ML^2T^{-2}A^{-2}$ (b) $ML^2T^{-4}A^{-3}$

(c) $ML^{-2}T^{-2}A^{-2}$ (d) $ML^2T^4A^3$

68. Dimensions of strain are [MP PET 1984; SCRA 1986]

(a) MLT^{-1} (b) ML^2T^{-1}

(c) MLT^{-2} (d) $M^0L^0T^0$

69. Dimensions of time in power are [EAMCET 1982]

(a) T^{-1} (b) T^{-2}

(c) T^{-3} (d) T^0

70. Dimensions of kinetic energy are

[Bihar PET 1983; DPET 1993; AFMC 1991]

(a) ML^2T^{-2} (b) M^2LT^{-1}

(c) ML^2T^{-1} (d) ML^3T^{-1}

71. Dimensional formula for torque is

[DPMT 1984; IIT 1983; CBSE PMT 1990; MNR 1988; AIIMS 2002; BHU 1995, 2001; RPMT 1999; RPET 2003; DCE 1999, 2000; DCE 2004]

(a) L^2MT^{-2} (b) $L^{-1}MT^{-2}$

(c) L^2MT^{-3} (d) LMT^{-2}

72. Dimensions of coefficient of viscosity are

[AIIMS 1993; CPMT 1992; Bihar PET 1984; MP PMT 1987, 89, 91; AFMC 1986; CBSE PMT 1992; KCET 1994; DCE 1999; AIEEE 2004; DPMT 2004]

(a) ML^2T^{-2} (b) ML^2T^{-1}

(c) $ML^{-1}T^{-1}$ (d) MLT

73. The dimension of quantity (L/RCV) is [Roorkee 1994]

(a) $[A]$ (b) $[A^2]$

(c) $[A^{-1}]$ (d) None of these

74. The dimension of the ratio of angular to linear momentum is

(a) $M^0L^1T^0$ (b) $M^1L^1T^{-1}$

(c) $M^1L^2T^{-1}$ (d) $M^{-1}L^{-1}T^{-1}$

75. The pair having the same dimensions is

[MP PET 1994; CPMT 1996]

(a) Angular momentum, work

(b) Work, torque

(c) Potential energy, linear momentum

(d) Kinetic energy, velocity

76. The dimensions of surface tension are

[MP PMT 1994, 99; UPSEAT 1999]

(a) $ML^{-1}T^{-2}$ (b) MLT^{-2}

(c) $ML^{-1}T^{-1}$ (d) MT^{-2}

77. In the following list, the only pair which have different dimensions, is [Manipal MEE 1995]

(a) Linear momentum and moment of a force

(b) Planck's constant and angular momentum

(c) Pressure and modulus of elasticity

(d) Torque and potential energy

78. If R and L represent respectively resistance and self inductance, which of the following combinations has the dimensions of frequency

[MP PMT 1996, 2000, 02; MP PET 1999]

(a) $\frac{R}{L}$ (b) $\frac{L}{R}$

(c) $\sqrt{\frac{R}{L}}$ (d) $\sqrt{\frac{L}{R}}$

79. If velocity v, acceleration A and force F are chosen as fundamental quantities, then the dimensional formula of angular momentum in terms of v, A and F would be

(a) $FA^{-1}v$ (b) Fv^3A^{-2}

(c) Fv^2A^{-1} (d) $F^2v^2A^{-1}$

80. The dimensions of permittivity ε_0 are

[MP PET 1997; AIIMS-2004; DCE-2003]

(a) $A^2T^2M^{-1}L^{-3}$ (b) $A^2T^4M^{-1}L^{-3}$

(c) $A^{-2}T^{-4}ML^3$ (d) $A^2T^{-4}M^{-1}L^{-3}$

81. Dimensions of the following three quantities are the same

[MP PET 1997]

(a) Work, energy, force

(b) Velocity, momentum, impulse

(c) Potential energy, kinetic energy, momentum

(d) Pressure, stress, coefficient of elasticity

82. The dimensions of Planck's constant and angular momentum are respectively [CPMT 1999; BCECE 2004]

(a) ML^2T^{-1} and MLT^{-1} (b) ML^2T^{-1} and ML^2T^{-1}

(c) MLT^{-1} and ML^2T^{-1} (d) MLT^{-1} and ML^2T^{-2}

83. Let $[\varepsilon_0]$ denotes the dimensional formula of the permittivity of the vacuum and $[\mu_0]$ that of the permeability of the vacuum. If $M = \text{mass}$, $L = \text{length}$, $T = \text{Time}$ and $I = \text{electric current}$, then [IIT 1998]

(a) $[\varepsilon_0] = M^{-1}L^{-3}T^2I$ (b) $[\varepsilon_0] = M^{-1}L^{-3}T^4I^2$

(c) $[\mu_0] = MLT^{-2}I^{-2}$ (d) $[\mu_0] = ML^2T^{-1}I$

84. Dimensions of CR are those of [MNR 1994]

[EAMCET (Engg.) 1995; AIIMS 1999]

(a) Frequency (b) Energy

(c) Time period (d) Current

85. The physical quantity that has no dimensions

[EAMCET (Engg.) 1995]

(a) Angular Velocity (b) Linear momentum

(c) Angular momentum (d) Strain

86. $ML^{-1}T^{-2}$ represents

[EAMCET (Med.) 1995; Pb. PMT 2001]

(a) Stress

(b) Young's Modulus

(c) Pressure

(d) All the above three quantities

87. Dimensions of magnetic field intensity is

[RPMT 1997; EAMCET (Med.) 2000; MP PET 2003]

(a) $[M^0L^{-1}T^0A^1]$ (b) $[MLT^{-1}A^{-1}]$

(c) $[ML^0T^{-2}A^{-1}]$ (d) $[MLT^{-2}A]$

88. The force F on a sphere of radius 'a' moving in a medium with velocity 'v' is given by $F = 6\pi\eta av$. The dimensions of η are [CBSE PMT 1997; DPMT 2000]

(a) $ML^{-1}T^{-1}$ (b) MT^{-1}

(c) MLT^{-2} (d) ML^{-3}

89. Which physical quantities have the same dimension [CPMT 1997]

(a) Couple of force and work

(b) Force and power

(c) Latent heat and specific heat

(d) Work and power

90. Two quantities A and B have different dimensions. Which mathematical operation given below is physically meaningful

(a) A/B (b) $A+B$

(c) $A-B$ (d) None

91. Given that v is speed, r is the radius and g is the acceleration due to gravity. Which of the following is dimensionless

(a) v^2/rg (b) v^2r/g

(c) v^2g/r (d) v^2rg

92. The physical quantity which has the dimensional formula M^1T^{-3} is [CET 1998]

(a) Surface tension (b) Solar constant

(c) Density (d) Compressibility

93. A force F is given by $F = at + bt^2$, where t is time. What are the dimensions of a and b [AFMC 2001; BHU 1998, 2005]

(a) MLT^{-3} and ML^2T^{-4} (b) MLT^{-3} and MLT^{-4}

(c) MLT^{-1} and MLT^0 (d) MLT^{-4} and MLT^1

94. The dimensions of inter atomic force constant are [UPSEAT 1999]

(a) MT^{-2} (b) MLT^{-1}

(c) MLT^{-2} (d) $ML^{-1}T^{-1}$

95. If the speed of light (c), acceleration due to gravity (g) and pressure (p) are taken as the fundamental quantities, then the dimension of gravitational constant is [AMU (Med.) 1999]

(a) $c^2g^0p^{-2}$ (b) $c^0g^2p^{-1}$

(c) cg^3p^{-2} (d) $c^{-1}g^0p^{-1}$

96. If the time period (T) of vibration of a liquid drop depends on surface tension (S), radius (r) of the drop and density (ρ) of the liquid, then the expression of T is [AMU (Med.) 2000]

(a) $T = k\sqrt{\rho r^3/S}$ (b) $T = k\sqrt{\rho^{1/2}r^3/S}$

(c) $T = k\sqrt{\rho r^3/S^{1/2}}$ (d) None of these

97. $ML^3T^{-1}Q^{-2}$ is dimension of [RPET 2000]

(a) Resistivity (b) Conductivity

(c) Resistance (d) None of these

98. Dimension of electric current is [CBSE PMT 2000]

(a) $[M^0L^0T^{-1}Q]$ (b) $[ML^2T^{-1}Q]$

(c) $[M^2LT^{-1}Q]$ (d) $[M^2L^2T^{-1}Q]$

99. The fundamental physical quantities that have same dimensions in the dimensional formulae of torque and angular momentum are

(a) Mass, time (b) Time, length

(c) Mass, length (d) Time, mole

100. If pressure P, velocity V and time T are taken as fundamental physical quantities, the dimensional formula of force is

(a) PV^2T^2 (b) $P^{-1}V^2T^{-2}$

(c) PVT^2 (d) $P^{-1}VT^2$

101. The physical quantity which has dimensional formula as that of $\frac{\text{Energy}}{\text{Mass} \times \text{Length}}$ is [CPMT 1997] [EAMCET (Eng.) 2000]

(a) Force (b) Power

(c) Pressure (d) Acceleration

102. If energy (E), velocity (v) and force (F) be taken as fundamental quantity, then what are the dimensions of mass [CET 1998] [AMU 2000]

(a) Ev^2 (b) Ev^{-2}

(c) Fv^{-1} (d) Fv^{-2}

103. Dimensions of luminous flux are [UPSEAT 2001]

(a) ML^2T^{-2} (b) ML^2T^{-3}

(c) ML^2T^{-1} (d) MLT^{-2}

104. A physcial quantity x depends on quantities y and z as follows: $x = Ay + B\tan Cz$, where A, B and C are constants. Which of the following do not have the same dimensions

(a) x and B (b) C and z^{-1}

(c) y and B/A (d) x and A

105. Which of the following pair does not have similar dimensions

(a) Stress and pressure

(b) Angle and strain

(c) Tension and surface tension

(d) Planck's constant and angular momentum

106. Out of the following which pair of quantities do not have same dimensions [RPET 2001]

(a) Planck's constant and angular momentum

(b) Work and energy

(c) Pressure and Young's modulus

(d) Torque & moment of inertia

107. Identify the pair which has different dimensions [KCET 2001]

(a) Planck's constant and angular momentum

(b) Impulse and linear momentum

(c) Angular momentum and frequency

(d) Pressure and Young's modulus

108. The dimensional formula $M^0L^2T^{-2}$ stands for [KCET 2001]

(a) Torque

(b) Angular momentum

(c) Latent heat

(d) Coefficient of thermal conductivity

109. Which of the following represents the dimensions of *Farad* [AMU (Med.) 2002]

(a) $M^{-1}L^{-2}T^4A^2$ (b) $ML^2T^2A^{-2}$

(c) $ML^2T^2A^{-1}$ (d) $MT^{-2}A^{-1}$

110. If L, C and R denote the inductance, capacitance and resistance respectively, the dimensional formula for C^2LR is [UPSEAT 2002]

(a) $[ML^{-2}T^{-1}I^0]$ (b) $[M^0L^0T^3I^0]$

(c) $[M^{-1}L^{-2}T^6I^2]$ (d) $[M^0L^0T^2I^0]$

111. If the velocity of light (c), gravitational constant (G) and Planck's constant (h) are chosen as fundamental units, then the dimensions of mass in new system is [UPSEAT 2002]

(a) $c^{1/2}G^{1/2}h^{1/2}$ (b) $c^{1/2}G^{1/2}h^{-1/2}$

(c) $c^{1/2}G^{-1/2}h^{1/2}$ (d) $c^{-1/2}G^{1/2}h^{1/2}$

112. Dimensions of charge are [DPMT 2002]
(a) $M^0L^0T^{-1}A^{-1}$ (b) $MLTA^{-1}$
(c) $T^{-1}A$ (d) TA

113. According to Newton, the viscous force acting between liquid layers of area A and velocity gradient $\Delta v/\Delta z$ is given by $F=-\eta A\frac{\Delta v}{\Delta z}$ where η is constant called coefficient of viscosity. The dimension of η are [JIPMER 2001, 02]
(a) $[ML^2T^{-2}]$ (b) $[ML^{-1}T^{-1}]$
(c) $[ML^{-2}T^{-2}]$ (d) $[M^0L^0T^0]$

114. Identify the pair whose dimensions are equal [AIEEE 2002]
(a) Torque and work (b) Stress and energy
(c) Force and stress (d) Force and work

115. The dimensions of pressure is equal to [AIEEE 2002]
(a) Force per unit volume
(b) Energy per unit volume
(c) Force
(d) Energy

116. Which of the two have same dimensions [AIEEE 2002]
(a) Force and strain
(b) Force and stress
(c) Angular velocity and frequency
(d) Energy and strain

117. An object is moving through the liquid. The viscous damping force acting on it is proportional to the velocity. Then dimension of constant of proportionality is [Orissa JEE 2002]
(a) $ML^{-1}T^{-1}$ (b) MLT^{-1}
(c) M^0LT^{-1} (d) ML^0T^{-1}

118. The dimensions of emf in MKS is [CPMT 2002]
(a) $ML^{-1}T^{-2}Q^{-2}$ (b) $ML^2T^{-2}Q^{-2}$
(c) $MLT^{-2}Q^{-1}$ (d) $ML^2T^{-2}Q^{-1}$

119. Which of the following quantities is dimensionless [MP PET 2002]
(a) Gravitational constant (b) Planck's constant
(c) Power of a convex lens (d) None

120. The dimensional formula for Boltzmann's constant is [MP PET 2002; Pb. PET 2001]
(a) $[ML^2T^{-2}\theta^{-1}]$ (b) $[ML^2T^{-2}]$
(c) $[ML^0T^{-2}\theta^{-1}]$ (d) $[ML^{-2}T^{-1}\theta^{-1}]$

121. The dimensions of K in the equation $W=\frac{1}{2}Kx^2$ is [Orissa JEE 2003]
(a) $M^1L^0T^{-2}$ (b) $M^0L^1T^{-1}$
(c) $M^1L^1T^{-2}$ (d) $M^1L^0T^{-1}$

122. The physical quantities not having same dimensions are [AIEEE 2003]
(a) Speed and $(\mu_0\varepsilon_0)^{-1/2}$
(b) Torque and work
(c) Momentum and Planck's constant
(d) Stress and Young's modules

123. Dimension of R is [AFMC 2003; AIIMS 2005]
(a) ML^2T^{-1} (b) $ML^2T^{-3}A^{-2}$
(c) $ML^{-1}T^{-2}$ (d) None of these

124. The dimensional formula of relative density is [CPMT 2003]
(a) ML^{-3} (b) LT^{-1}
(c) MLT^{-2} (d) Dimensionless

125. The dimensional formula for young's modulus is [BHU 2003; CPMT 2004]
(a) $ML^{-1}T^{-2}$ (b) M^0LT^{-2}
(c) MLT^{-2} (d) ML^2T^{-2}

126. Frequency is the function of density (ρ), length (a) and surface tension (T). Then its value is [BHU 2003]
(a) $k\rho^{1/2}a^{3/2}/\sqrt{T}$ (b) $k\rho^{3/2}a^{3/2}/\sqrt{T}$
(c) $k\rho^{1/2}a^{3/2}/T^{3/4}$ (d) $k\rho^{1/2}a^{1/2}/T^{3/2}$

127. The dimensions of electric potential are [UPSEAT 2003]
(a) $[ML^2T^{-2}Q^{-1}]$ (b) $[MLT^{-2}Q^{-1}]$
(c) $[ML^2T^{-1}Q]$ (d) $[ML^2T^{-2}Q]$

128. Dimensions of potential energy are [MP PET 2003]
(a) MLT^{-1} (b) ML^2T^{-2}
(c) $ML^{-1}T^{-2}$ (d) $ML^{-1}T^{-1}$

129. The dimension of $\frac{R}{L}$ are [MP PET 2003]
(a) T^2 (b) T
(c) T^{-1} (d) T^{-2}

130. The dimensions of shear modulus are [MP PMT 2004]
(a) MLT^{-1} (b) ML^2T^{-2}
(c) $ML^{-1}T^{-2}$ (d) MLT^{-2}

131. Pressure gradient has the same dimension as that of [AFMC 2004]
(a) Velocity gradient (b) Potential gradient
(c) Energy gradient (d) None of these

132. If force (F), length (L) and time (T) are assumed to be fundamental units, then the dimensional formula of the mass will be
(a) $FL^{-1}T^2$ (b) $FL^{-1}T^{-2}$
(c) $FL^{-1}T^{-1}$ (d) FL^2T^2

133. The dimensions of universal gas constant is [Pb. PET 2003]
(a) $[ML^2T^{-2}\theta^{-1}]$ (b) $[M^2LT^{-2}\theta]$
(c) $[ML^3T^{-1}\theta^{-1}]$ (d) None of these

134. In the relation $y=a\cos(\omega t-kx)$, the dimensional formula for k is
(a) $[M^0L^{-1}T^{-1}]$ (b) $[M^0LT^{-1}]$
(c) $[M^0L^{-1}T^0]$ (d) $[M^0LT]$

135. Position of a body with acceleration 'a' is given by $x=Ka^mt^n$, here t is time. Find dimension of m and n. [Orissa JEE 2005]
(a) $m=1$, $n=1$ (b) $m=1, n=2$
(c) $m=2, n=1$ (d) $m=2, n=2$

136. "Pascal-Second" has dimension of [AFMC 2005]
(a) Force (b) Energy
(c) Pressure (d) Coefficient of viscosity

137. In a system of units if force (F), acceleration (A) and time (T) are taken as fundamental units then the dimensional formula of energy is [BHU 2005]
(a) FA^2T (b) FAT^2

(c) F^2AT (d) FAT

138. Out of the following pair, which one does not have identical dimensions [AIEEE 2005]

(a) Moment of inertia and moment of force

(b) Work and torque

(c) Angular momentum and Planck's constant

(d) Impulse and momentum

139. The ratio of the dimension of Planck's constant and that of moment of inertia is the dimension of [CBSE PMT 2005]

(a) Frequency (b) Velocity

(c) Angular momentum (d) Time

140. Which of the following group have different dimension [IIT JEE 2005]

(a) Potential difference, EMF, voltage

(b) Pressure, stress, young's modulus

(c) Heat, energy, work-done

(d) Dipole moment, electric flux, electric field

141. Out of following four dimensional quantities, which one quantity is to be called a dimensional constant [KCET 2005]

(a) Acceleration due to gravity

(b) Surface tension of water

(c) Weight of a standard kilogram mass

(d) The velocity of light in vacuum

142. Density of a liquid in CGS system is 0.625 g/cm^3. What is its magnitude in SI system [J&K CET 2005]

(a) 0.625 (b) 0.0625

(c) 0.00625 (d) 625

Errors of Measurement

1. The period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$ where l is about 100 *cm* and is known to have 1*mm* accuracy. The period is about 2*s*. The time of 100 oscillations is measured by a stop watch of least count 0.1 s. The percentage error in g is

(a) 0.1% (b) 1%

(c) 0.2% (d) 0.8%

2. The percentage errors in the measurement of mass and speed are 2% and 3% respectively. How much will be the maximum error in the estimation of the kinetic energy obtained by measuring mass and speed

(a) 11% (b) 8%

(c) 5% (d) 1%

3. The random error in the arithmetic mean of 100 observations is x; then random error in the arithmetic mean of 400 observations would be

(a) $4x$ (b) $\frac{1}{4}x$

(c) $2x$ (d) $\frac{1}{2}x$

4. What is the number of significant figures in 0.310×10^{3}

(a) 2 (b) 3

(c) 4 (d) 6

5. Error in the measurement of radius of a sphere is 1%. The error in the calculated value of its volume is [AFMC 2005]

(a) 1% (b) 3%

(c) 5% (d) 7%

6. The mean time period of *second*s pendulum is 2.00*s* and mean absolute error in the time period is 0.05*s*. To express maximum estimate of error, the time period should be written as

(a) (2.00 ± 0.01) *s* (b) $(2.00 + 0.025)$ *s*

(c) (2.00 ± 0.05) *s* (d) (2.00 ± 0.10) *s*

7. A body travels uniformly a distance of (13.8 ± 0.2) *m* in a time (4.0 ± 0.3) s. The velocity of the body within error limits is

(a) (3.45 ± 0.2) *ms* (b) (3.45 ± 0.3) *ms*

(c) (3.45 ± 0.4) *ms* (d) (3.45 ± 0.5) *ms*

8. The percentage error in the above problem is

(a) 7% (b) 5.95%

(c) 8.95% (d) 9.85%

9. The unit of percentage error is

(a) Same as that of physical quantity

(b) Different from that of physical quantity

(c) Percentage error is unit less

(d) Errors have got their own units which are different from that of physical quantity measured

10. The decimal equivalent of 1/20 upto three significant figures is

(a) 0.0500 (b) 0.05000

(c) 0.0050 (d) 5.0×10^{-2}

11. Accuracy of measurement is determined by

(a) Absolute error (b) Percentage error

(c) Both (d) None of these

12. The radius of a sphere is (5.3 ± 0.1) *cm*. The percentage error in its volume is

(a) $\frac{0.1}{5.3}\times100$ (b) $3\times\frac{0.1}{5.3}\times100$

(c) $\frac{0.1\times100}{3.53}$ (d) $3+\frac{0.1}{5.3}\times100$

13. A thin copper wire of length l *metre* increases in length by 2% when heated through 10°C. What is the percentage increase in area when a square copper sheet of length l *metre* is heated through $10^\circ C$

(a) 4% (b) 8%

(c) 16% (d) None of the above

14. In the context of accuracy of measurement and significant figures in expressing results of experiment, which of the following is/are correct

(1) Out of the two measurements 50.14 *cm* and 0.00025 *ampere*, the first one has greater accuracy

(2) If one travels 478 *km* by rail and 397 *m.* by road, the total distance travelled is 478 *km*.

(a) Only (1) is correct (b) Only (2) is correct

(c) Both are correct (d) None of them is correct.

15. A physical parameter *a* can be determined by measuring the parameters b, c, d and e using the relation $a = b^\alpha c^\beta / d^\gamma e^\delta$. If the maximum errors in the measurement of b, c, d and e are b_1 %, c_1 %, d_1 % and e_1 %, then the maximum error in the value of *a* determined by the experiment is

(a) $(b_1 + c_1 + d_1 + e_1)$%

(b) $(b_1 + c_1 - d_1 - e_1)$%

(c) $(\alpha b_1 + \beta c_1 - \gamma d_1 - \delta e_1)$%

(d) $(\alpha b_1 + \beta c_1 + \gamma d_1 + \delta e_1)\%$

16. The relative density of material of a body is found by weighing it first in air and then in water. If the weight in air is (5.00 ± 0.05) *Newton* and weight in water is (4.00 ± 0.05) *Newton*. Then the relative density along with the maximum permissible percentage error is

(a) $5.0 \pm 11\%$ (b) $5.0 \pm 1\%$

(c) $5.0 \pm 6\%$ (d) $1.25 \pm 5\%$

17. The resistance $R = \frac{V}{i}$ where $V = 100 \pm 5$ *volts* and $i = 10 \pm 0.2$ *amperes*. What is the total error in R

(a) 5% (b) 7%

(c) 5.2% (d) $\frac{5}{2}\%$

18. The period of oscillation of a simple pendulum in the experiment is recorded as 2.63 s, 2.56 s, 2.42 s, 2.71 s and 2.80 s respectively. The average absolute error is

(a) 0.1 s (b) 0.11 s

(c) 0.01 s (d) 1.0 s

19. The length of a cylinder is measured with a meter rod having least count 0.1 *cm*. Its diameter is measured with vernier calipers having least count 0.01 *cm*. Given that length is 5.0 *cm*. and radius is 2.0 *cm*. The percentage error in the calculated value of the volume will be

(a) 1% (b) 2%

(c) 3% (d) 4%

20. In an experiment, the following observation's were recorded : L = 2.820 *m*, M = 3.00 *kg*, l = 0.087 *cm*, Diameter D = 0.041 *cm*

Taking g = 9.81 m/s^2 using the formula, $Y = \frac{4MgL}{\pi D^2 l}$, the maximum permissible error in Y is

(a) 7.96% (b) 4.56%

(c) 6.50% (d) 8.42%

21. According to *Joule*'s law of heating, heat produced $H = I^2 Rt$, where I is current, R is resistance and t is time. If the errors in the measurement of I, R and t are 3%, 4% and 6% respectively then error in the measurement of H is

(a) $\pm 17\%$ (b) $\pm 16\%$

(c) $\pm 19\%$ (d) $\pm 25\%$

22. If there is a positive error of 50% in the measurement of velocity of a body, then the error in the measurement of kinetic energy is

(a) 25% (b) 50%

(c) 100% (d) 125%

23. A physical quantity P is given by $P = \frac{A^3 B^{\frac{1}{2}}}{C^{-4} D^{\frac{3}{2}}}$. The quantity which brings in the maximum percentage error in P is

(a) A (b) B

(c) C (d) D

24. If $L = 2.331\,cm$, $B = 2.1\,cm$, then $L + B =$ [DCE 2003]

(a) 4.431 *cm* (b) 4.43 *cm*

(c) 4.4 *cm* (d) 4 *cm*

25. The number of significant figures in all the given numbers 25.12, 2009, 4.156 and 1.217×10^{-4} is [Pb. PET 2003]

(a) 1 (b) 2

(c) 3 (d) 4

26. If the length of rod A is 3.25 ± 0.01 *cm* and that of B is 4.19 ± 0.01 *cm* then the rod B is longer than rod A by

[J&K CET 2005]

(a) 0.94 ± 0.00 *cm* (b) 0.94 ± 0.01 *cm*

(c) 0.94 ± 0.02 *cm* (d) 0.94 ± 0.005 *cm*

27. A physical quantity is given by $X = M^a L^b T^c$. The percentage error in measurement of M, L and T are α, β and γ respectively. Then maximum percentage error in the quantity X is

(a) $a\alpha + b\beta + c\gamma$ (b) $a\alpha + b\beta - c\gamma$

(c) $\frac{a}{\alpha} + \frac{b}{\beta} + \frac{c}{\gamma}$ (d) None of these

28. A physical quantity A is related to four observable a, b, c and d as follows, $A = \frac{a^2 b^3}{c\sqrt{d}}$, the percentage errors of measurement in a, b, c and d are 1%,3%,2% and 2% respectively. What is the percentage error in the quantity A

[Kerala PET 2005]

(a) 12% (b) 7%

(c) 5% (d) 14%

Critical Thinking

Objective Questions

1. If the acceleration due to gravity is $10\,ms^{-2}$ and the units of length and time are changed in kilometer and hour respectively, the numerical value of the acceleration is

[Kerala PET 2002]

(a) 360000 (b) 72,000

(c) 36,000 (d) 129600

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

(a) $\frac{1}{RC}$ (b) $\frac{R}{L}$

(c) $\frac{1}{\sqrt{LC}}$ (d) $\frac{C}{L}$

3. 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

(a) $M^0 LT^2$ (b) $M^0 L^2 T^{-4}$

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

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

(a) Only numerically correct

(b) Only dimensionally correct

(c) Both numerically and dimensionally correct

(d) Neither numerically nor dimensionally correct

5. 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]

(a) $x = \frac{1}{2}, y = \frac{1}{2}$ (b) $x = \frac{1}{2}, z = \frac{1}{2}$

(c) $y = \frac{1}{2}, z = \frac{3}{2}$ (d) $y = -\frac{3}{2}, z = \frac{1}{2}$

6. 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 η 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]

(a) $2\pi\sqrt{\frac{M\eta}{L}}$ (b) $2\pi\sqrt{\frac{L}{M\eta}}$

(c) $2\pi\sqrt{\frac{ML}{\eta}}$ (d) $2\pi\sqrt{\frac{M}{\eta L}}$

7. The pair(s) of physical quantities that have the same dimensions, is (are) [IIT 1995]

(a) Reynolds number and coefficient of friction
(b) Latent heat and gravitational potential
(c) Curie and frequency of a light wave
(d) Planck's constant and torque

8. The speed of light (c), gravitational constant (G) and Planck's constant (h) are taken as the fundamental units in a system. The dimension of time in this new system should be

(a) $G^{1/2}h^{1/2}c^{-5/2}$ (b) $G^{-1/2}h^{1/2}c^{1/2}$

(c) $G^{1/2}h^{1/2}c^{-3/2}$ (d) $G^{1/2}h^{1/2}c^{1/2}$

9. If the constant of gravitation (G), Planck's constant (h) and the velocity of light (c) be chosen as fundamental units. The dimension of the radius of gyration is [AMU (Eng.) 1999]

(a) $h^{1/2}c^{-3/2}G^{1/2}$ (b) $h^{1/2}c^{3/2}G^{1/2}$

(c) $h^{1/2}c^{-3/2}G^{-1/2}$ (d) $h^{-1/2}c^{-3/2}G^{1/2}$

10. $X = 3YZ^2$ find dimension of Y in (MKSA) system, if X and Z are the dimension of capacity and magnetic field respectively

(a) $M^{-3}L^{-2}T^{-4}A^{-1}$ (b) ML^{-2}

(c) $M^{-3}L^{-2}T^{4}A^{4}$ (d) $M^{-3}L^{-2}T^{8}A^{4}$

11. 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 θ is the temperature. The dimensional formula of β will be [IIT (Screening) 2004]

(a) $[M^0L^2T^0]$ (b) $[M^1L^2T^1]$

(c) $[M^1L^0T^{-1}]$ (d) $[M^0L^2T^{-1}]$

12. The frequency of vibration of string is given by $\nu = \frac{p}{2l}\left[\frac{F}{m}\right]^{1/2}$. Here p is number of segments in the string and l is the length. The dimensional formula for m will be [BHU 2004]

(a) $[M^0LT^{-1}]$ (b) $[ML^0T^{-1}]$

(c) $[ML^{-1}T^0]$ (d) $[M^0L^0T^0]$

13. **Column I** **Column II**

Column I	Column II
(i) Curie	(A) MLT^{-2}
(ii) Light year	(B) M
(iii) Dielectric strength	(C) Dimensionless
(iv) Atomic weight	(D) 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]

(a) (i) G, (ii) H, (iii) C, (iv) B, (v) C
(b) (i) D, (ii) H, (iii) I, (iv) B, (v) G
(c) (i) G, (ii) H, (iii) I, (iv) B, (v) G
(d) None of the above

14. 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 [IIT (Screening) 2004]

(a) 1 (b) 2

(c) 3 (d) 4

15. If 97.52 is divided by 2.54, the correct result in terms of significant figures is

(a) 38.4 (b) 38.3937

(c) 38.394 (d) 38.39

Assertion & Reason

For AIIMS Aspirants

Choose any one of the following four responses :

(a) *If both assertion and reason are true and the reason is the correct explanation of the assertion.*
(b) *If both assertion and reason are true but reason is not the correct explanation of the assertion.*
(c) *If assertion is true but reason is false.*
(d) *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. [MP PMT 2003]

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 $[ML^{-1}T^0]$.

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 $\bar{\nu} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, 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 : Radian is the unit of distance.
Reason : One radian is the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

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

18. 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.

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

20. Assertion : The time period of a pendulum is given by the formula, $T = 2\pi\sqrt{g/l}$.
Reason : According to the principle of homogeneity of dimensions, only that formula is correct in which the dimensions of L.H.S. is equal to dimensions of R.H.S.

21. 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.

22. 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.

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

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

25. Assertion : The quantity $(1/\sqrt{\mu_0 \varepsilon_0})$ is dimensionally equal to velocity and numerically equal to velocity of light.
Reason : μ_0 is permeability of free space and ε_0 is the permittivity of free space.

Answers

Units

1	c	2	b	3	d	4	c	5	c
6	d	7	c	8	d	9	c	10	c
11	a	12	c	13	c	14	b	15	d
16	d	17	c	18	a	19	b	20	d
21	d	22	a	23	a	24	b	25	d
26	b	27	d	28	d	29	d	30	b
31	a	32	b	33	a	34	b	35	a
36	b	37	a	38	b	39	b	40	b
41	d	42	c	43	c, b	44	c	45	b
46	a	47	c	48	c	49	a	50	a
51	b	52	b	53	c	54	c	55	c
56	c	57	b	58	a	59	c	60	a
61	c	62	c	63	d	64	d	65	b
66	c	67	a	68	b	69	c	70	b
71	d	72	b	73	b	74	d	75	c
76	b	77	b	78	b	79	c	80	c
81	a	82	a	83	d	84	c	85	b
86	d	87	d	88	b	89	a	90	c
91	a	92	d	93	b	94	a	95	d
96	a	97	b	98	a	99	d	100	b
101	d	102	d	103	a	104	a	105	d
106	b	107	b	108	b	109	b		

Dimensions

1	a	2	c	3	b	4	a	5	b
6	c	7	c	8	b	9	ad	10	a
11	d	12	b	13	a	14	a	15	a
16	b	17	b	18	d	19	a	20	c
21	b	22	a	23	b	24	d	25	a
26	d	27	a	28	d	29	d	30	d
31	c	32	c	33	a	34	a	35	b
36	b	37	c	38	c	39	a	40	b
41	a	42	b	43	d	44	d	45	a

46	d	47	b	48	d	49	b	50	a
51	a	52	d	53	b	54	b	55	c
56	c	57	d	58	a	59	a	60	c
61	b	62	b	63	c	64	a	65	a
66	b	67	a	68	d	69	c	70	a
71	a	72	c	73	c	74	a	75	b
76	d	77	a	78	a	79	b	80	b
81	d	82	b	83	bc	84	c	85	d
86	d	87	c	88	a	89	a	90	a
91	a	92	b	93	b	94	a	95	b
96	a	97	a	98	a	99	c	100	a
101	d	102	b	103	b	104	d	105	c
106	d	107	c	108	c	109	a	110	b
111	c	112	d	113	b	114	a	115	b
116	c	117	d	118	d	119	d	120	a
121	a	122	c	123	b	124	d	125	a
126	a	127	a	128	b	129	c	130	c
131	d	132	a	133	a	134	c	135	b
136	d	137	b	138	a	139	a	140	d
141	d	142	d						

Errors of Measurement

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

Critical Thinking Questions

1	d	2	d	3	d	4	c	5	bd
6	d	7	abc	8	a	9	a	10	d
11	a	12	c	13	a	14	d	15	a

Assertion and Reason

1	c	2	d	3	a	4	c	5	d
6	a	7	a	8	c	9	b	10	a
11	c	12	c	13	a	14	c	15	c
16	e	17	b	18	c	19	c	20	e
21	b	22	a	23	c	24	a	25	b

Answers and Solutions

Units

1. (c) Light year is a distance which light travels in one year.
2. (b) Because magnitude is absolute.
3. (d) *Watt=Joule/second* = *Ampere×volt* = *Ampere×Ohm*
4. (c) Impulse = change in momentum = $F \times t$
   So the unit of momentum will be equal to *Newton-sec.*
5. (c) Unit of energy will be $kg - m^2/\text{sec}^2$
6. (d) It is by standard definition.
7. (c) $1\ nm = 10^{-9} m = 10^{-7} cm$
8. (d) $1\ micron = 10^{-6} m = 10^{-4} cm$
9. (c) *Watt* = *Joule/sec.*
10. (c) $F = \frac{Gm_1m_2}{d^2}$; $\therefore\ G = \frac{Fd^2}{m_1m_2} = Nm^2/kg^2$
11. (a)
12. (c) Angular acceleration $= \frac{\text{Angular velocity}}{\text{Time}} = \frac{rad}{\text{sec}^2}$
13. (c) Stefan's law is $E = \sigma(T^4) \Rightarrow \sigma = \frac{E}{T^4}$
   where, $E = \frac{\text{Energy}}{\text{Area} \times \text{Time}} = \frac{\text{Watt}}{m^2}$
   $\sigma = \frac{\text{Watt-}m^{-2}}{K^4} = Watt\text{–}m^{-2}K^{-4}$
14. (b) *Kg-m/sec* is the unit of linear momentum
15. (d) ct^2 must have dimensions of L
   $\Rightarrow$ c must have dimensions of L/T^2 *i.e.* LT^{-2}.
16. (d) $\tau = \frac{dL}{dt} \Rightarrow dL = \tau \times dt = r \times F \times dt$
   i.e. the unit of angular momentum is *joule-second.*
17. (c)
18. (a) Volume of cube = a^3
   Surface area of cube = $6a^2$
   according to problem $a = 6a \Rightarrow a = 6$
   $\therefore V = a^3 = 216\, units.$
19. (b) $6 \times 10^{-5} = 60 \times 10^{-6} = 60\, microns$
20. (d)
21. (d) Because temperature is a fundamental quantity.
22. (a)
23. (a) 1 C.G.S unit of density = 1000 M.K.S. unit of density
   $\Rightarrow 0.5\ gm/cc = 500\, kg/m^3$
24. (b)
25. (d)
26. (b) Mach number $= \frac{\text{Velocity of object}}{\text{Velocity of sound}}$.
27. (d)
28. (d) $E = -\frac{dV}{dx}$
29. (d)
30. (b) Surface tension = $\frac{\text{Force}}{\text{Length}}$ = *Newtons / metre*
31. (a)
32. (b) $L = \frac{\phi}{I} = \frac{Wb}{A} = Henry$.
33. (a) $\frac{L}{R}$ is a time constant of *L-R* circuit so *Henry/ohm* can be expressed as *second.*
34. (b) $mv = kg\left(\frac{m}{\text{sec}}\right)$
35. (a) Quantities of similar dimensions can be added or subtracted so unit of *a* will be same as that of velocity.
36. (b) $1\ MeV = 10^6\ eV$
37. (a) Energy (E) = $F \times d \Rightarrow F = \frac{E}{d}$ so *Erg/metre* can be the unit of force.
38. (b) Potential energy $= mgh = g\left(\frac{cm}{\text{sec}^2}\right)cm = g\left(\frac{cm}{\text{sec}}\right)^2$
39. (b) $\frac{watt}{ampere} = volt$
40. (b)
41. (d)
42. (c)
43. (b,c)
44. (c) Energy = force × distance, so if both are increased by 4 times then energy will increase by 16 times.
45. (b) 1 Oersted = 1 Gauss = 10^{-4} *Tesla*
46. (a) Charge = current × time
47. (c) $R = \rho\frac{L}{A} \Rightarrow \rho = \frac{RA}{L} = ohm \times cm$
48. (c)
49. (a) Astronomical unit of distance.
50. (a) Physical quantity (p) = Numerical value (n) × Unit (u)
   If physical quantity remains constant then $n \propto 1/u$ $\therefore$ $n_1u_1 = n_2u_2$.
51. (b) $1 eV = 1.6 \times 10^{-19} coulomb \times 1 volt = 1.6 \times 10^{-19} J$.
52. (b) $1\, kWh = 1 \times 10^3 \times 3600\, W \times \text{sec} = 36 \times 10^5 J$
53. (c) According to the definition.
54. (c)
55. (c) As $I = MR^2 = kg - m^2$
56. (c) $\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{N}{m^2}$
57. (b) $\frac{Q}{t} = \sigma AT^4 \Rightarrow \sigma = Jm^{-2}s^{-1}K^{-4}$
58. (a) M = Pole strength × length
   $= amp - metre \times metre = amp - metre^2$
59. (c) *Curie* = *disintegration/second*
60. (a)
61. (c) Pico prefix used for 10^{-12}

62. (c)

63. (d) Unit of $e.m.f.$ = *volt* = *joule/coulomb*

64. (d)

65. (b)

66. (c) $Y = \frac{F}{A} \cdot \frac{L}{\Delta L} = \frac{dyne}{cm^2} = \frac{10^{-5} N}{10^{-4} m^2} = 0.1 N/m^2$

67. (a) $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\text{Force/Area}}{\text{Dimensionless}} \Rightarrow Y \equiv \text{Pressure}$.

68. (b) $1\ yard = 36\ inches = 36 \times 2.54\ cm = 0.9144 m$.

69. (c) $1\ \text{fermi} = 10^{-15} metre$

70. (b)

71. (d)

72. (b)

73. (b)

74. (d) 1 *Newton* = 10^5 *Dyne*

75. (c) $[x] = [bt^2] \Rightarrow [b] = [x/t^2] = km/s^2$

76. (b) Units of a and PV^2 are same and equal to $dyne \times cm^4$.

77. (b)

78. (b)

79. (c) Impulse = Force × time $= (kg\text{-}m/s^2) \times s = kg\text{-}m/s$

80. (c)

81. (a) $K = C + 273.15$

82. (a)

83. (d)

84. (c)

85. (b)

86. (d) *Watt* is a unit of power

87. (d) $1\text{lightyear} = 9.46 \times 10^{15}\ meter$

88. (b) $V = \frac{W}{m}$ so, SI unit = $\frac{Joule}{kg}$

89. (a)

90. (c) $n_2 = n_1 \left(\frac{M_1}{M_2}\right)^1 \left(\frac{L_1}{L_2}\right)^1 \left(\frac{T}{T_2}\right)^{-2}$

$= 100 \left(\frac{gm}{kg}\right)^1 \left(\frac{cm}{m}\right)^1 \left(\frac{\sec}{\min}\right)^{-2}$

$= 100 \left(\frac{gm}{10^3 gm}\right)^1 \left(\frac{cm}{10^2 cm}\right)^1 \left(\frac{\sec}{60 \sec}\right)^{-2}$

$n_2 = \frac{3600}{10^3} = 3.6$

91. (a) $[L/R]$ is a time constant so its unit is *Second*.

92. (d) Poission ratio is a unitless quantity.

93. (b)

94. (a)

95. (d) $P = nu \therefore n \propto \frac{1}{u}$

96. (a) 1 *Faraday* = 96500 *coulomb*.

97. (b)

98. (a)

99. (d)

100. (b)

101. (d) $F = \frac{1}{4\pi \in} \frac{q_1 q_2}{r^2} \Rightarrow \in = \frac{1}{4\pi} \frac{q_1 q_2}{Fr^2} = C^2 m^{-2} N^{-1}$

102. (d) *Joule-sec* is the unit of angular momentum where as other units are of energy.

103. (a) $T = \frac{F}{l} = Nm^{-1}$

104. (a) Because in S.I. system there are seven fundamental quantities.

105. (d) $[\eta] = ML^{-1}T^{-1}$ so its unit will be *kg/m-sec*.

106. (b)

107. (b)

108. (b) According to the definition.

109. (b) Pyrometer is used for measurement of temperature.

Dimensions

1. (a) Pressure $= \frac{\text{Force}}{\text{Area}} = ML^{-1}T^{-2}$

Stress $= \frac{\text{Restoring force}}{\text{Area}} = ML^{-1}T^{-2}$

2. (c) Strain $= \frac{\Delta L}{L} \Rightarrow$ dimensionless quantity

3. (b) Power $= \frac{\text{Work}}{\text{Time}} = \frac{ML^2T^{-2}}{T} = ML^2T^{-3}$

4. (a) *Calorie* is the unit of heat *i.e.*, energy.

So dimensions of energy $= ML^2T^{-2}$

5. (b) Angular momentum = $mvr = MLT^{-1} \times L = ML^2T^{-1}$

6. (c) $\frac{L}{R}$ = Time constant

7. (c) Impulse = change in momentum so dimensions of both quantities will be same and equal to MLT^{-1}

8. (b) $RC = T$

$\because\ [R] = [ML^2T^{-3}I^{-2}]$ and $[C] = [M^{-1}L^{-2}T^4I^2]$

9. (a,d) [Torque] = [work] = $[ML^2T^{-2}]$

[Light year] = [Wavelength] = $[L]$

10. (a) $Q = mL \Rightarrow L = \frac{Q}{m}$ (Heat is a form of energy)

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

11. (d) Volume elasticity = $\frac{\text{Force/Area}}{\text{Volume strain}}$

Strain is dimensionless, so

$= \frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

12. (b) $F = \frac{Gm_1m_2}{d^2} \Rightarrow G = \frac{Fd^2}{m_1m_2}$

$\therefore\ [G] = \frac{[MLT^{-2}][L^2]}{[M^2]} = [M^{-1}L^3T^{-2}]$

13. (a) Angular velocity = $\frac{\theta}{t}$, $[\omega] = \frac{[M^0L^0T^0]}{[T]} = [T^{-1}]$

14. (a) Power = $\frac{\text{Work done}}{\text{Time}} = \left[\frac{ML^2T^{-2}}{T}\right] = [ML^2T^{-3}]$

15. (a) Couple = Force × Arm length = $[MLT^{-2}][L] = [ML^2T^{-2}]$

16. (b) Angular momentum = mvr

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

17. (b) Impulse = Force × Time = $[MLT^{-2}][T] = [MLT^{-1}]$

18. (d) Modulus of rigidity = $\frac{\text{Shear stress}}{\text{Shear strain}} = [ML^{-1}T^{-2}]$

19. (a)

20. (c) $E = hv \Rightarrow [ML^2T^{-2}] = [h][T^{-1}] \Rightarrow [h] = [ML^2T^{-1}]$

21. (b) Moment of inertia $= mr^2 = [M][L^2]$

Moment of Force = Force × Perpendicular distance

$= [MLT^{-2}][L] = [ML^2T^{-2}]$

22. (a) Momentum = $mv = [MLT^{-1}]$

Impulse = Force × Time = $[MLT^{-2}] \times [T] = [MLT^{-1}]$

23. (b) Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{\text{Energy}}{\text{Volume}} = ML^{-1}T^{-2}$

24. (d) $[h] = [\text{Angular momentum}] = [ML^2T^{-1}]$

25. (a) By principle of dimensional homogenity $\left[\frac{a}{V^2}\right] = [P]$

$\therefore [a] = [P][V^2] = [ML^{-1}T^{-2}] \times [L^6] = [ML^5T^{-2}]$

26. (d) $\frac{1}{2}CV^2$ = Stored energy in a capacitor = $[ML^2T^{-2}]$

27. (a) $\frac{1}{2}Li^2$ = Stored energy in an inductor = $[ML^2T^{-2}]$

28. (d) Energy per unit volume = $\frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

Force per unit area = $\frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

Product of voltage and charge per unit volume

$= \frac{V \times Q}{\text{Volume}} = \frac{VIt}{\text{Volume}} = \frac{\text{Power} \times \text{Time}}{\text{Volume}}$

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

Angular momentum per unit mass = $\frac{[ML^2T^{-1}]}{[M]} = [L^2T^{-1}]$

So angular momentum per unit mass has different dimension.

29. (d) Time constant $\tau = [T]$ and Viscosity $\eta = [ML^{-1}T^{-1}]$

For options (a), (b) and (c) dimensions are not matching with time constant.

30. (d) By putting the dimensions of each quantity both the sides we get $[T^{-1}] = [M]^x[MT^{-2}]^y$

Now comparing the dimensions of quantities in both sides we get $x + y = 0$ and $2y = 1$ $\therefore$ $x = -\frac{1}{2}, y = \frac{1}{2}$

31. (c) m = linear density = mass per unit length = $\left[\frac{M}{L}\right]$

A= force $= [MLT^{-2}]$ $\therefore$ $[B] = \frac{[A]}{[m]} = \frac{[MLT^{-2}]}{[ML^{-1}]} = [L^2T^{-2}]$

This is same dimension as that of latent heat.

32. (c) Let $v^x = kg^y\lambda^z\rho^\delta$. Now by substituting the dimensions of each quantities and equating the powers of M, L and T we get $\delta = 0$ and $x = 2, y = 1, z = 1$.

33. (a) *Farad* is the unit of capacitance and $C = \frac{Q}{V} = \frac{[Q]}{[ML^2T^{-2}Q^{-1}]} = M^{-1}L^{-2}T^2Q^2$

34. (a) $\rho = \frac{RA}{l}$ *i.e.* dimension of resistivity is $[ML^3T^{-1}Q^{-2}]$

35. (b) From the principle of homogenity $\left(\frac{x}{v}\right)$ has dimensions of T.

36. (b) $\frac{dQ}{dt} = -KA\left(\frac{d\theta}{dx}\right)$

$\Rightarrow [K] = \frac{[ML^2T^{-2}]}{[T]} \times \frac{[L]}{[L^2][K]} = MLT^{-3}K^{-1}$

37. (c) Stress = $\frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

38. (c)

39. (a) $[C] = \left(\frac{Q}{V}\right) = \left(\frac{Q^2}{W}\right) = \left[\frac{A^2T^2}{ML^2T^{-2}}\right] = [M^{-1}L^{-2}T^4A^2]$

40. (b) Momentum = mv = $[MLT^{-1}]$

41. (a) $Q = [ML^2T^{-2}]$ (All energies have same dimension)

42. (b) $f = \frac{1}{2\pi\sqrt{LC}} \Rightarrow LC = \frac{1}{f^2} = [M^0L^0T^2]$

43. (d) Energy = Work done [Dimensionally]

44. (d) $\frac{L}{R}$ = Time constant.

45. (a) By substituting the dimension of each quantity we get $T = [ML^{-1}T^{-2}]^a[L^{-3}M]^b[MT^{-2}]^c$

By solving we get a = – 3/2, b = 1/2 and c = 1

46. (d)

47. (b) $v \propto g^ph^q$ (given)

By substituting the dimension of each quantity and comparing the powers in both sides we get $[LT^{-1}] = [LT^{-2}]^p[L]^q$

$\Rightarrow p + q = 1, -2p = -1, \therefore p = \frac{1}{2}, q = \frac{1}{2}$

48. (d) [Planck constant] = $[ML^2T^{-1}]$ and

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

49. (b) Frequency $= \frac{1}{T} = [M^0L^0T^{-1}]$

50. (a) Power = $\dfrac{\text{Energy}}{\text{Time}}$

51. (a) By substituting dimension of each quantity in R.H.S. of option (a) we get $\left[\dfrac{mg}{\eta r}\right] = \left[\dfrac{M \times LT^{-2}}{ML^{-1}T^{-1} \times L}\right] = [LT^{-1}]$.

This option gives the dimension of velocity.

52. (d) $[\varepsilon_0 L]$ = [C] $\therefore$ $X = \dfrac{\varepsilon_0 LV}{t} = \dfrac{C \times V}{t} = \dfrac{Q}{t}$ = current

53. (b) $C = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}} \Rightarrow \mu_0 \varepsilon_0 = \left(\dfrac{1}{C^2}\right)$ (where C = velocity of light)

$\therefore$ $[\mu_0 \varepsilon_0] = L^{-2}T^2$

54. (b)

55. (c) $[X] = [F] \times [\rho] = [MLT^{-2}] \times \left[\dfrac{M}{L^3}\right] = [M^2L^{-2}T^{-2}]$

56. (c) Both are the formula of energy . $\left(E = \dfrac{1}{2}CV^2 = \dfrac{1}{2}LI^2\right)$

57. (d) Acceleration = $\dfrac{\text{distance}}{\text{time}^2} \Rightarrow A = LT^{-2} \Rightarrow L = AT^2$

58. (a) $\dfrac{1}{\sqrt{\varepsilon_0 \mu_0}} = C =$ velocity of light

59. (a) According to problem muscle × speed = power

$\therefore$ muscle = $\dfrac{\text{power}}{\text{speed}} = \dfrac{ML^2T^{-3}}{LT^{-1}} = MLT^{-2}$

60. (c)

61. (b) Wave number = $\dfrac{1}{\lambda}$ $\therefore$ dimension is $[M^0L^{-1}T^0]$

62. (b) [Pressure] =[stress] = $[ML^{-1}T^{-2}]$

63. (c)

64. (a) $F = \dfrac{\mu_0}{4\pi} \dfrac{2I_1I_2 l}{r} \Rightarrow \mu_0 = [F][A]^{-2} = [MLT^{-2}A^{-2}]$

65. (a) $\phi = BA = \dfrac{F}{I \times L} A = \dfrac{[MLT^{-2}]\,[L^2]}{[A]\,[L]} = [ML^2T^{-2}A^{-1}]$

66. (b) By substituting the dimension of given quantities $[ML^{-1}T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z = [MLT]^0$

By comparing the power of M, L, T in both sides $x + y = 0$

$-x + z = 0$ .....(ii)

$-2x - 3y - z = 0$ ...(iii)

The only values of x, y, z satisfying (i), (ii) and (iii) corresponds to (b).

67. (a) $E = \dfrac{1}{2}Li^2$ hence $L = [ML^2T^{-2}A^{-2}]$

68. (d) Strain is dimensionless.

69. (c) Dimensions of power is $[ML^2T^{-3}]$

70. (a) Kinetic energy = $\dfrac{1}{2}mv^2 = M[LT^{-1}]^2 = [ML^2T^{-2}]$

71. (a) Torque = force × distance = $[ML^2T^{-2}]$

72. (c) $F = -\eta . A \dfrac{dv}{dx} \Rightarrow [\eta] = [ML^{-1}T^{-1}]$

73. (c) $\dfrac{L}{RCV} = \left[\dfrac{L}{R}\right] \dfrac{1}{CV} = \dfrac{T}{Q} = [A^{-1}]$

74. (a) $\dfrac{\text{Angular momentum}}{\text{Linear momentum}} = \dfrac{mvr}{mv} = r = [M^0L^1T^0]$

75. (b) Dimension of work and torque = $[ML^2T^{-2}]$

76. (d) Surface tension = $\dfrac{\text{Force}}{\text{Length}} = \dfrac{[MLT^{-2}]}{L} = [MT^{-2}]$

77. (a) Linear momentum = Mass × Velocity = $[MLT^{-1}]$

Moment of a force = Force × Distance = $[ML^2T^{-2}]$

78. (a) $\dfrac{R}{L} = \dfrac{V/I}{V \times T/I} = \dfrac{1}{T}$ = Frequency

79. (b) $L \propto v^x A^y F^z \Rightarrow L = kv^x A^y F^z$

Putting the dimensions in the above relation

$[ML^2T^{-1}] = k[LT^{-1}]^x [LT^{-2}]^y [MLT^{-2}]^z$

$\Rightarrow [ML^2T^{-1}] = k[M^z L^{x+y+z} T^{-x-2y-2z}]$

Comparing the powers of M, L and T

$z = 1$ ...(i)

$x + y + z = 2$ ...(ii)

$-x - 2y - 2z = -1$ ...(iii)

On solving (i), (ii) and (iii) $x = 3, y = -2, z = 1$

So dimension of L in terms of v, A and f

$[L] = [Fv^3A^{-2}]$

80. (b) $F = \dfrac{1}{4\pi\varepsilon_0} \dfrac{q_1 q_2}{r^2}$

$\Rightarrow \varepsilon_0 = \dfrac{|q_1||q_2|}{[F][r^2]} = \dfrac{[A^2T^2]}{[MLT^{-2}][L^2]} = [A^2T^4M^{-1}L^{-3}]$

81. (d) [Pressure] = [Stress] = [coefficient of elasticity] = $[ML^{-1}T^{-2}]$

82. (b)

83. (b, c)

84. (c) Capacity × Resistance = $\dfrac{\text{Charge}}{\text{Potential}} \times \dfrac{\text{Volt}}{\text{amp}}$

= $\dfrac{\text{amp} \times \text{second} \times \text{Volt}}{\text{Volt} \times \text{amp}}$ = Second .....(i)

85. (d) Strain has no dimensions.

86. (d)

87. (c) $B = \dfrac{F}{IL} = \dfrac{[MLT^{-2}]}{[A][L]} = [MT^{-2}A^{-1}]$

88. (a) $\eta = \dfrac{F}{av} = \dfrac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$

89. (a) Couple of force = $|\vec{r} \times \vec{F}| = [ML^2T^{-2}]$

Work = $[\vec{F}.\vec{d}] = [ML^2T^{-2}]$

90. (a) Quantities having different dimensions can only be divided or multiplied but they cannot be added or subtracted.

91. (a) Angle of banking : $\tan\theta = \dfrac{v^2}{rg}$. *i.e.* $\dfrac{v^2}{rg}$ is dimensionless.

92. (b) Solar constant is energy received per unit area per unit time *i.e.*
$$\frac{[ML^2T^{-2}]}{[L^2][T]}=[M^1T^{-3}]$$

93. (b) From the principle of dimensional homogenity
$[a]=\left[\frac{F}{t}\right]=[MLT^{-3}]$ and $[b]=\left[\frac{F}{t^2}\right]=[MLT^{-4}]$

94. (a) $K=Y\times r_0=[ML^{-1}T^{-2}]\times[L]=[MT^{-2}]$
Y = Young's modulus and r_0 = Interatomic distance

95. (b) Let $[G]\propto c^x g^y p^z$
by substituting the following dimensions :
$[G]=[M^{-1}L^3T^{-2}],[c]=[LT^{-1}],[g]=[LT^{-2}]$
$[p]=[ML^{-1}T^{-2}]$
and by comparing the powers of both sides
we can get $x=0, y=2, z=-1$
$\therefore\ [G]\propto c^0g^2p^{-1}$

96. (a) Let $T\propto S^x r^y \rho^z$
by substituting the dimension of $[T]=[T]$
$[S]=[MT^{-2}],[r]=[L],[\rho]=[ML^{-3}]$
and by comparing the power of both the sides
$x=-1/2, y=3/2, z=1/2$
so $T\propto\sqrt{\rho r^3/S}\Rightarrow T=k\sqrt{\frac{\rho r^3}{S}}$

97. (a) Resistivity $[\rho]=\frac{[R].[A]}{[l]}$ where $[R]=[ML^2T^{-1}Q^{-2}]$
$\therefore\ [\rho]=[ML^3T^{-1}Q^{-2}]$

98. (a) $I=\frac{Q}{t}=\frac{[Q]}{[T]}=[M^0L^0T^{-1}Q]$

99. (c) Torque = $[ML^2T^{-2}]$, Angular momentum = $[ML^2T^{-1}]$ So mass and length have the same dimensions

100. (a) Let $F\propto P^xV^yT^z$
by substituting the following dimensions :
$[P]=[ML^{-1}T^{-2}]\ [V]=[LT^{-1}],[T]=[T]$
and comparing the dimension of both sides
$x=1, y=2, z=2$, so $F=PV^2T^2$

101. (d) $\frac{\text{Energy}}{\text{mass}\times\text{length}}=\frac{[ML^2T^{-2}]}{[M][L]}=[LT^{-2}]$

102. (b) Let $m\propto E^xv^yF^z$
By substituting the following dimensions :
$[E]=[ML^2T^{-2}],[v]=[LT^{-1}],[F]=[MLT^{-2}]$
and by equating the both sides
$x=1, y=-2, z=0$. So $[m]=[Ev^{-2}]$

103. (b)

104. (d) $x=Ay+B\tan Cz$
From the dimensional homogenity
$[x]=[Ay]=[B]\Rightarrow\left[\frac{x}{A}\right]=[y]=\left[\frac{B}{A}\right]$
$[Cz]=[M^0L^0T^0]=$ Dimension less
x and B; C and Z^{-1}; y and $\frac{B}{A}$ have the same dimension but x and A have the different dimensions.

105. (c) Tension = $[MLT^{-2}]$, Surface Tension = $[MT^{-2}]$

106. (d) Torque = $[ML^2T^{-2}]$, Moment of inertia = $[ML^2]$

107. (c) Angular momentum = $[ML^2T^{-1}]$, Frequency = $[T^{-1}]$

108. (c) Latent Heat $L=\frac{Q}{m}=\frac{\text{Energy}}{\text{mass}}=\frac{[ML^2T^{-2}]}{[M]}=[L^2T^{-2}]$

109. (a) $C=\frac{Q}{V}=\frac{[AT]}{[ML^2T^{-3}A^{-1}]}=[M^{-1}L^{-2}T^4A^2]$

110. (b) $C^2LR=[C^2L^2]\times\left[\frac{R}{L}\right]=[T^4]\times\left[\frac{1}{T}\right]=[T^3]$
As $\left[\frac{L}{R}\right]=T$ and $\sqrt{LC}=T$

111. (c) Let $m\propto C^xG^yh^z$
By substituting the following dimensions :
$[C]=LT^{-1};[G]=[M^{-1}L^3T^{-2}]$ and $[h]=[ML^2T^{-1}]$
Now comparing both sides we will get
$x=1/2; y=-1/2, z=+1/2$
So $m\propto c^{1/2}G^{-1/2}h^{1/2}$

112. (d) Charge = Current × Time $=[AT]$

113. (b) $F=-\eta A\frac{\Delta v}{\Delta z}\Rightarrow[\eta]=[ML^{-1}T^{-1}]$
As $F=[MLT^{-2}],\ A=[L^2],\frac{\Delta v}{\Delta z}=[T^{-1}]$

114. (a)

115. (b) $\frac{\text{Energy}}{\text{Volume}}=\frac{ML^2T^{-2}}{L^3}=[ML^{-1}T^{-2}]$ = Pressure

116. (c) $\omega=\frac{d\theta}{dt}=[T^{-1}]$ and frequency $[n]=[T^{-1}]$

117. (d) $F\propto v\Rightarrow F=kv\Rightarrow[k]=\left[\frac{F}{v}\right]=\left[\frac{MLT^{-2}}{LT^{-1}}\right]=[MT^{-1}]$

118. (d) $e=L\frac{di}{dt}\Rightarrow[e]=[ML^2T^{-2}A^{-2}]\left[\frac{A}{T}\right]$
$[e]=\left[\frac{ML^2T^{-2}}{AT}\right]=[ML^2T^{-2}Q^{-1}]$

119. (d) $[G]=[M^{-1}L^3T^{-2}];[h]=[ML^2T^{-1}]$
Power = $\frac{1}{\text{focal length}}=[L^{-1}]$
All quantities have dimensions

120. (a) $k=\left[\frac{R}{N}\right]=[ML^2T^{-2}\theta^{-1}]$

121. (a) $W=\frac{1}{2}kx^2\Rightarrow[k]=\frac{[W]}{[x^2]}=\left[\frac{ML^2T^{-2}}{L^2}\right]=[MT^{-2}]$

122. (c) Momentum $[MLT^{-1}]$, Planck's constant $[ML^2T^{-1}]$

123. (b) $R = \frac{V}{I} = \left[\frac{ML^2T^{-3}A^{-1}}{A}\right] = [ML^2T^{-3}A^{-2}]$

124. (d) Relative density $= \frac{\text{Density of substance}}{\text{density of water}} = [M^0L^0T^0]$

125. (a)

126. (a) Let $n = k\rho^a a^b T^c$ where $[\rho] = [ML^{-3}], [a] = [L]$ and $[T] = [MT^{-2}]$

Comparing both sides, we get

$a = \frac{1}{2}, b = \frac{3}{2}$ and $c = \frac{-1}{2}$ $\therefore$ $\eta = \frac{k\rho^{1/2}a^{3/2}}{\sqrt{T}}$

127. (a) $V = \frac{W}{Q} = [ML^2T^{-2}Q^{-1}]$

128. (b)

129. (c) L/R is a time constant so $(R/L) = T^{-1}$

130. (c) Shear modulus $= \frac{\text{Shearing stress}}{\text{Shearing strain}} = \frac{F}{A\theta} = [ML^{-1}T^{-2}]$

131. (d) Velocity gradient $= \frac{v}{x} = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$

Potential gradient $= \frac{V}{x} = \frac{[ML^2T^{-3}A^{-1}]}{[L]} = [MLT^{-3}A^{-1}]$

Energy gradient $= \frac{E}{x} = \frac{[ML^2T^2]}{[L]} = [MLT^{-2}]$

and pressure gradient $= \frac{P}{x} = \frac{[ML^{-1}T^{-2}]}{[L]} = [ML^{-2}T^{-2}]$

132. (a) Let $m = KF^aL^bT^c$

Substituting the dimension of

$[F] = [MLT^{-2}],\ [C] = [L]\ and\ [T] = [T]$

and comparing both sides, we get $m = FL^{-1}T^{-2}$

133. (a) $\because R = \frac{PV}{T} = \left[\frac{ML^{-1}T^{-2} \times L^3}{\theta}\right] = [ML^2T^{-2}\theta^{-1}]$

134. (c) $[Kx]$ = Dimension of ωt = (dimensionless) hence $K = \frac{1}{X} = \frac{1}{L} = [L^{-1}]$ $\therefore$ $[K] = [L^{-1}]$

135. (b) As $x = Ka^m \times t^n$

$[M^0LT^0] = [LT^{-2}]^m [T]^n = [L^mT^{-2m+n}]$

$\therefore$ $m = 1$ and $-2m + n = 0 \Rightarrow n = 2$.

136. (d) $NSm^{-2} = Nm^{-2} \times S$ = Pascal-second.

137. (b) $E = KF^aA^bT^c$

$[ML^2T^{-2}] = [MLT^{-2}]^a[LT^{-2}]^b[T]^c$

$[ML^2T^{-2}] = [M^aL^{a+b}T^{-2a-2b+c}]$

$\therefore$ $a = 1$, $a + b = 2 \Rightarrow b = 1$

and $-2a - 2b + c = -2 \Rightarrow c = 2$

$\therefore$ $E = KFAT^2$.

138. (a)

139. (a) $\frac{h}{I} = \left[\frac{ML^2T^{-1}}{ML^2}\right] = [T^{-1}]$

140. (d)

141. (d)

142. (d) CGS SI

$N_1U_1 = N_2U_2$

$N_1[M_1L_1^{-3}] = N_2[M_2L_2^{-3}]$

$\therefore$ $N_2 = N_1\left[\frac{M_1}{M_2}\right] \times \left[\frac{L_1}{L_2}\right]^{-3} = 0.625\left[\frac{1g}{1kg}\right] \times \left[\frac{1cm}{1m}\right]^{-3}$

$= 0.625 \times 10^{-3} \times 10^6 = 625$

Errors of Measurement

1. (c) $T = 2\pi\sqrt{l/g} \Rightarrow T^2 = 4\pi^2 l/g \Rightarrow g = \frac{4\pi^2 l}{T^2}$

Here % error in l = $\frac{1mm}{100cm} \times 100 = \frac{0.1}{100} \times 100 = 0.1\%$

and % error in T = $\frac{0.1}{2 \times 100} \times 100 = 0.05\%$

$\therefore$ % error in g = % error in l + 2(% error in T)

$= 0.1 + 2 \times 0.05$ = 0.2 %

2. (b) $\therefore E = \frac{1}{2}mv^2$

$\therefore$% Error in K.E.

= % error in mass + 2 × % error in velocity

= 2 + 2 × 3 = 8 %

3. (b)

4. (b) Number of significant figures are 3, because 10⁻ is decimal multiplier.

5. (b) $\because V = \frac{4}{3}\pi r^3$

$\therefore$ % error is volume $= 3 \times \%$ error in radius

$= 3 \times 1$ = 3%

6. (c) Mean time period T = 2.00 *sec*

& Mean absolute error $= \Delta T$ = 0.05 *sec.*

To express maximum estimate of error, the time period should be written as (2.00 ± 0.05) *sec*

7. (b) Here, $S = (13.8 \pm 0.2)\, m$

and $t = (4.0 \pm 0.3)$ *sec*

Expressing it in percentage error, we have,

$S = 13.8 \pm \frac{0.2}{13.8} \times 100\% = 13.8 \pm 1.4\%$

and $t = 4.0 \pm \frac{0.3}{4} \times 100\% = 4 \pm 7.5\%$

$\because V = \frac{s}{t} = \frac{13.8 \pm 1.4}{4 \pm 7.5} = (3.45 \pm 0.3)\, m/s.$

8. (c) % error in velocity = %error in L + %error in t

$= \frac{0.2}{13.8} \times 100 + \frac{0.3}{4} \times 100$

= 1.44 + 7.5 = 8.94 %

9. (c)

10. (a) $\frac{1}{20} = 0.05$

$\therefore$ Decimal equivalent upto 3 significant figures is 0.0500

11. (b)

12. (b) $\because V = \frac{4}{3}\pi r^3$

$\therefore$ % error in volume

$= 3 \times \%$ error in radius.

$= \frac{3 \times 0.1}{5.3} \times 100$

13. (a) Since percentage increase in length = 2 %

Hence, percentage increase in area of square sheet

$= 2 \times 2\%$ = 4%

14. (c) Since for 50.14 *cm*, significant number = 4 and for 0.00025, significant numbers = 2

15. (d) $a = b^{\alpha} c^{\beta} / d^{\gamma} e^{\delta}$

So maximum error in a is given by

$$\left(\frac{\Delta a}{a} \times 100\right)_{max} = \alpha . \frac{\Delta b}{b} \times 100 + \beta . \frac{\Delta c}{c} \times 100$$

$$+ \gamma . \frac{\Delta d}{d} \times 100 + \delta . \frac{\Delta e}{e} \times 100$$

$$= (\alpha b_1 + \beta c_1 + \gamma d_1 + \delta e_1)\%$$

16. (a) Weight in air $= (5.00 \pm 0.05)\,N$

Weight in water $= (4.00 \pm 0.05)\,N$

Loss of weight in water $= (1.00 \pm 0.1)\,N$

Now relative density $= \frac{\text{weight in air}}{\text{weight loss in water}}$

i.e. $R.D = \frac{5.00 \pm 0.05}{1.00 \pm 0.1}$

Now relative density with max permissible error

$$= \frac{5.00}{1.00} \pm \left(\frac{0.05}{5.00} + \frac{0.1}{1.00}\right) \times 100 = 5.0 \pm (1 + 10)\%$$

$= 5.0 \pm 11\%$

17. (b) $\therefore \left(\frac{\Delta R}{R} \times 100\right)_{max} = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

$$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = (5 + 2)\% = 7\%$$

18. (b) Average value $= \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$

$= 2.62$ sec

Now $|\Delta T_1| = 2.63 - 2.62 = 0.01$

$|\Delta T_2| = 2.62 - 2.56 = 0.06$

$|\Delta T_3| = 2.62 - 2.42 = 0.20$

$|\Delta T_4| = 2.71 - 2.62 = 0.09$

$|\Delta T_5| = 2.80 - 2.62 = 0.18$

Mean absolute error

$$\Delta T = \frac{|\Delta T_1| + |\Delta T_2| + |\Delta T_3| + |\Delta T_4| + |\Delta T_5|}{5}$$

$$= \frac{0.54}{5} = 0.108 = 0.11 sec$$

19. (c) Volume of cylinder $V = \pi r^2 l$

Percentage error in volume

$$\frac{\Delta V}{V} \times 100 = \frac{2\Delta r}{r} \times 100 + \frac{\Delta l}{l} \times 100$$

$$= \left(2 \times \frac{0.01}{2.0} \times 100 + \frac{0.1}{5.0} \times 100\right) = (1 + 2)\% = 3\%$$

20. (c) $Y = \frac{4MgL}{\pi D^2 l}$ so maximum permissible error in Y

$$= \frac{\Delta Y}{Y} \times 100 = \left(\frac{\Delta M}{M} + \frac{\Delta g}{g} + \frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta l}{l}\right) \times 100$$

$$= \left(\frac{1}{300} + \frac{1}{981} + \frac{1}{2820} + 2 \times \frac{1}{41} + \frac{1}{87}\right) \times 100$$

$= 0.065 \times 100 = 6.5\%$

21. (b) $H = I^2 R t$

$$\therefore \frac{\Delta H}{H} \times 100 = \left(\frac{2\Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t}\right) \times 100$$

$= (2 \times 3 + 4 + 6)\% = 16\%$

22. (d) Kinetic energy $E = \frac{1}{2} m v^2$

$$\therefore \frac{\Delta E}{E} \times 100 = \frac{v'^2 - v^2}{v^2} \times 100$$

$= [(1.5)^2 - 1] \times 100$

$\therefore \frac{\Delta E}{E} \times 100 = 125\%$

23. (c) Quantity C has maximum power. So it brings maximum error in P.

24. (c) Given, $L = 2.331\ cm$

$= 2.33$ (correct upto two decimal places)

and $B = 2.1\ cm = 2.10\ cm$

$\therefore L + B = 2.33 + 2.10 = 4.43\ cm. = 4.4\ cm$

Since minimum significant figure is 2.

25. (d) The number of significant figures in all of the given number is 4.

26. (c)

27. (a) Percentage error in $X = a\alpha + b\beta + c\gamma$

28. (d) Percentage error in A

$$= \left(2 \times 1 + 3 \times 3 + 1 \times 2 + \frac{1}{2} \times 2\right)\% = 14\%$$

Critical Thinking Questions

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

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

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

3. (d) $[n]$ = Number of particles crossing a unit area in unit time = $[L^{-2}T^{-1}]$

$[n_2] = [n_1]$ = number of particles per unit volume = $[L^{-3}]$

$[x_2] = [x_1]$ = positions

$\therefore D = \frac{[n][x_2 - x_1]}{[n_2 - n_1]} = \frac{[L^{-2}T^{-1}] \times [L]}{[L^{-3}]} = [L^2T^{-1}]$

4. (c) We can derive this equation from equations of motion so it is numerically correct.

S_t = distance travelled in t 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.

5. (b, d) Length $\propto Gch$

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

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

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

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

7. (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 $[ML^2T^{-2}]$

8. (a) Time $\propto c^x G^y h^z \Rightarrow T = kc^x G^y h^z$

Putting the dimensions in the above relation

$\Rightarrow [M^0L^0T^1] = [LT^{-1}]^x [M^{-1}L^3T^{-2}]^y [ML^2T^{-1}]^z$

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

Comparing the powers of M, L and T

$-y + z = 0$ ...(i)

$x + 3y + 2z = 0$ ...(ii)

$-x - 2y - z = 1$ ...(iii)

On solving equations (i) and (ii) and (iii)

$x = \frac{-5}{2}, y = z = \frac{1}{2}$

Hence dimension of time are $[G^{1/2}h^{1/2}c^{-5/2}]$

9. (a) Let radius of gyration $[k] \propto [h]^x [c]^y [G]^z$

By substituting the dimension of $[k] = [L]$

$[h] = [ML^2T^{-1}], [c] = [LT^{-1}], [G] = [M^{-1}L^3T^{-2}]$

and by comparing the power of both sides

we can get $x = 1/2, y = -3/2, z = 1/2$

So dimension of radius of gyration are $[h]^{1/2}[c]^{-3/2}[G]^{1/2}$

10. (d) $Y = \frac{X}{3Z^2} = \frac{M^{-1}L^{-2}T^4A^2}{[MT^{-2}A^{-1}]^2} = [M^{-3}L^{-2}T^8A^4]$

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

12. (c) $v = \frac{P}{2l}\left[\frac{F}{m}\right]^{1/2} \Rightarrow v^2 = \frac{P^2}{4l^2}\left[\frac{F}{m}\right] \therefore m \propto \frac{F}{l^2v^2}$

$\Rightarrow [m] = \left[\frac{MLT^{-2}}{L^2T^{-2}}\right] = [ML^{-1}T^0]$

13. (a)

14. (d) $\because$ Density, $\rho = \frac{M}{V} = \frac{M}{\pi r^2 L}$

$\Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 2\frac{\Delta r}{r} + \frac{\Delta L}{L}$

$= \frac{0.003}{0.3} + 2 \times \frac{0.005}{0.5} + \frac{0.06}{6}$

$= 0.01 + 0.02 + 0.01 = 0.04$

$\therefore$ Percentage error $= \frac{\Delta\rho}{\rho} \times 100 = 0.04 \times 100 = 4\%$

15. (a)

Assertion and Reason

1. (c) Light year and wavelength both represents the distance, so both has dimension of length not of time.
2. (d) Light year measures distance and year measures time. One light year is the distance traveled by light in one year.
3. (a) Addition and subtraction can be done between quantities having same dimension.
4. (c) Density is not always mass per unit volume.
5. (d) Rate of flow of liquid is expressed as the volume of liquid flowing per second and it has dimension $[L^3T^{-1}]$.
6. (a)
7. (a) 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. (c) Since zeros placed to the left of the number are never significant, but zeros placed to right of the number are significant.

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

10. (a) 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. (c) Because density can be derived from fundamental quantities.

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

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

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

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

16. (e) Radian is the unit of plane angle.

17. (b) 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. = $1.5 \times 10^{11} m$; $1Å = 10^{-10} m$.

18. (c) We know that $Q = n_1u_1 = n_2u_2$ are the two units of measurement of the quantity *Q* and *n, n* are their respective numerical values. From relation $Q_1 = n_1u_1 = n_2u_2$, *nu* = constant $\Rightarrow n \propto 1/u$ *i.e.,* smaller the unit of measurement, greater is its numerical value.

19. (c) 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.

20. (e) Let us write the dimension of various quantities on two sides of the given relation.

L.H.S. $= T = [T]$, R.H.S. $= 2\pi\sqrt{g/l} = \sqrt{\frac{LT^{-2}}{L}} = [T^{-1}]$

($\because 2\pi$ has no dimension). As dimensions of L.H.S. is not equal to dimension of R.H.S. therefore according to principle of homogeneity the relation

$T = 2\pi\sqrt{g/l}$ is not valid.

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

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

22. (a) 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

23. (c) Avogadro number (*N*) represents the number of atoms in 1 gram mole of an element, i.e. it has the dimensions of mole.

24. (a) 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.

25. (b) 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.

Units, Dimensions and Measurement

SET Self Evaluation Test - 1

1. The surface tension of a liquid is $70\ dyne/cm$. In MKS system its value is [CPMT 1973, 74; AFMC 1996; BHU 2002]
 (a) $70\ N/m$ (b) $7\times10^{-2}\ N/m$
 (c) $7\times10^{3}\ N/m$ (d) $7\times10^{2}\ N/m$

2. The SI unit of universal gas constant (R) is [MP Board 1988; JIPMER 1993; AFMC 1996; MP PMT 1987, 94; CPMT 1984, 87; UPSEAT 1999]
 (a) $Watt K^{-1}mol^{-1}$
 (b) $Newton\ K^{-1}mol^{-1}$
 (c) $Joule\ K^{-1}\ mol^{-1}$
 (d) $Erg K^{-1}\ mol^{-1}$

3. The unit of permittivity of free space ε_0 is [MP PET 1993; MP PMT 2003; CBSE PMT 2004]
 (a) *Coulomb/Newton-metre*
 (b) Newton-$metre^2/Coulomb^2$
 (c) Coulomb^2/(*Newton-metre*)^2
 (d) $Coulomb^2/Newton\text{-}metre^2$

4. The temperature of a body on Kelvin scale is found to be $X\ K$. When it is measured by a Fahrenheit thermometer, it is found to be X^0F. Then X is [UPSEAT 2000]
 (a) 301.25
 (b) 574.25
 (c) 313
 (d) 40

5. What are the units of $K = 1/4\pi\varepsilon_0$ [AFMC 2004]
 (a) $C^2N^{-1}m^{-2}$ (b) Nm^2C^{-2}
 (c) Nm^2C^2 (d) Unitless

6. The SI unit of surface tension is [DCE 2003]
 (a) *Dyne/cm* (b) *Newton/cm*
 (c) *Newton/metre* (d) *Newton-metre*

7. E, m, l and G denote energy, mass, angular momentum and gravitational constant respectively, then the dimension of $\frac{El^2}{m^5G^2}$ are [AIIMS 1985]
 (a) Angle (b) Length
 (c) Mass (d) Time

8. From the equation $\tan\theta = \frac{rg}{v^2}$, one can obtain the angle of banking θ for a cyclist taking a curve (the symbols have their usual meanings). Then say, it is
 (a) Both dimensionally and numerically correct
 (b) Neither numerically nor dimensionally correct
 (c) Dimensionally correct only
 (d) Numerically correct only

9. A dimensionally consistent relation for the volume V of a liquid of coefficient of viscosity η flowing per *second* through a tube of radius r and length l and having a pressure difference p across its end, is
 (a) $V = \frac{\pi p r^4}{8\eta l}$ (b) $V = \frac{\pi\eta l}{8pr^4}$
 (c) $V = \frac{8p\eta l}{\pi r^4}$ (d) $V = \frac{\pi p\eta}{8lr^4}$

10. The velocity v (in $cm/\sec$) of a particle is given in terms of time t (in *sec*) by the relation $v = at + \frac{b}{t+c}$; the dimensions of a, b and c are [CPMT 1990]
 (a) $a = L^2, b = T, c = LT^2$
 (b) $a = LT^2, b = LT, c = L$
 (c) $a = LT^{-2}, b = L, c = T$
 (d) $a = L, b = LT, c = T^2$

11. From the dimensional consideration, which of the following equation is correct [CPMT 1983]
 (a) $T = 2\pi\sqrt{\frac{R^3}{GM}}$ (b) $T = 2\pi\sqrt{\frac{GM}{R^3}}$
 (c) $T = 2\pi\sqrt{\frac{GM}{R^2}}$ (d) $T = 2\pi\sqrt{\frac{R^2}{GM}}$

12. The position of a particle at time t is given by the relation $x(t) = \left(\frac{v_0}{\alpha}\right)(1 - c^{-\alpha t})$, where v_0 is a constant and $\alpha > 0$. The dimensions of v_0 and α are respectively [CBSE PMT 1995]
 (a) $M^0L^1T^{-1}$ and T^{-1}
 (b) $M^0L^1T^0$ and T^{-1}
 (c) $M^0L^1T^{-1}$ and LT^{-2}
 (d) $M^0L^1T^{-1}$ and T

13. The equation of state of some gases can be expressed as $\left(P + \frac{a}{V^2}\right) = \frac{R\theta}{V}$ Where P is the pressure, V the volume, θ the absolute temperature and a and b are constants. The dimensional formula of a is

[UPSEAT 2002; Orissa PMT 2004]

(a) $[ML^5T^{-2}]$ (b) $[M^{-1}L^5T^{-2}]$

(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-5}T^{-2}]$

14. The dimensions of $\frac{a}{b}$ in the equation $P = \frac{a - t^2}{bx}$, where P is pressure, x is distance and t is time, are

[KCET 2003]

(a) MT^{-2} (b) M^2LT^{-3}

(c) ML^3T^{-1} (d) LT^{-3}

15. Dimensions of $\frac{1}{\mu_0\varepsilon_0}$, where symbols have their usual meaning, are [AIEEE 2003]

(a) $[LT^{-1}]$ (b) $[L^{-1}T]$

(c) $[L^{-2}T^2]$ (d) $[L^2T^{-2}]$

16. The dimensions of $e^2 / 4\pi\varepsilon_0 hc$, where e, ε_0, h and c are electronic charge, electric permittivity, Planck's constant and velocity of light in vacuum respectively [UPSEAT 2004]

(a) $[M^0L^0T^0]$ (b) $[M^1L^0T^0]$

(c) $[M^0L^1T^0]$ (d) $[M^0L^0T^1]$

17. If radius of the sphere is $(5.3 \pm 0.1)\,cm$. Then percentage error in its volume will be [Pb. PET 2000]

(a) $3 + 6.01 \times \frac{100}{5.3}$ (b) $\frac{1}{3} \times 0.01 \times \frac{100}{5.3}$

(c) $\left(\frac{3 \times 0.1}{5.3}\right) \times 100$ (d) $\frac{0.1}{5.3} \times 100$

18. 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 the measurement of force and length are respectively 4% and 2%, The maximum error in the measurement of pressure is

[CPMT 1993]

(a) 1% (b) 2%

(c) 6% (d) 8%

19. While measuring the acceleration due to gravity by a simple pendulum, a student makes a positive error of 1% in the length of the pendulum and a negative error of 3% in the value of time period. His percentage error in the measurement of g by the relation $g = 4\pi^2(l / T^2)$ will be

(a) 2% (b) 4%

(c) 7% (d) 10%

20. The length, breadth and thickness of a block are given by $l = 12\,cm, b = 6\,cm$ and $t = 2.45\,cm$

The volume of the block according to the idea of significant figures should be [CPMT 2004]

(a) $1 \times 10^2\ cm^3$ (b) $2 \times 10^2\ cm^3$

(c) $1.763 \times 10^2\ cm^3$ (d) None of these

Answers and Solutions

(SET -1)

1. (b) 1 $dyne = 10^{-5}$ $Newton$, $1\,cm = 10^{-2}\,m$

$$70\,\frac{dyne}{cm} = \frac{70\times 10^{-5}}{10^{-2}}\,\frac{N}{m}$$

$= 7\times 10^{-2}\,N/m$.

2. (c) $PV = nRT \Rightarrow R = \frac{PV}{nT} = \frac{Joule}{mole\times Kelvin} = JK^{-1}mol^{-1}$

3. (d) $F = \frac{1}{4\pi\varepsilon_0}.\frac{Q_1Q_2}{r^2}$

$$\Rightarrow \varepsilon_0 \propto \frac{Q^2}{F\times r^2}$$

So ε_0 has units of $Coulomb^2/Newton\text{-}m^2$

4. (b) $\frac{F-32}{9} = \frac{K-273}{5} \Rightarrow \frac{x-32}{9} = \frac{x-273}{5} \Rightarrow x = 574.25$

5. (b) Unit of $\varepsilon_0 = C^2/N\text{-}m^2$ $\therefore$ Unit of $K = Nm^2C^{-2}$

6. (c)

7. (a) $[E] = [ML^2T^{-2}]$, $[m] = [M]$, $[l] = [ML^2T^{-1}]$ and $[G] = [M^{-1}L^3T^{-2}]$ Substituting the dimension of above quantities in the given formula :

$$\frac{El^2}{m^5G^2} = \frac{[ML^2T^{-2}][ML^2T^{-1}]^2}{[M^5][M^{-1}L^3T^{-2}]^2} = \frac{M^3L^6T^{-4}}{M^3L^6T^{-4}} = [M^0L^0T^0]$$

8. (c) Given equation is dimensionally correct because both sides are dimensionless but numerically wrong because the correct equation is $\tan\theta = \frac{v^2}{rg}$.

9. (a) Formula for viscosity $\eta = \frac{\pi p r^4}{8Vl} \Rightarrow V = \frac{\pi p r^4}{8\eta l}$

10. (c) From the principle of dimensional homogenity $[v] = [at] \Rightarrow [a] = [LT^{-2}]$. Similarly $[b] = [L]$ and $[c] = [T]$

11. (a) By substituting the dimensions in $T = 2\pi\sqrt{\frac{R^3}{GM}}$

we get $\sqrt{\frac{L^3}{M^{-1}L^3T^{-2}\times M}} = T$

12. (a) Dimension of $\alpha t = [M^0L^0T^0]$ $\therefore$ $[\alpha] = [T^{-1}]$

Again $\left[\frac{v_0}{\alpha}\right] = [L]$ so $[v_0] = [LT^{-1}]$

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13. (a) By the principle of dimensional homogenity

$$[P] = \left[\frac{a}{V^2}\right] \Rightarrow [a] = [P]\times[V^2] = [ML^{-1}T^{-2}][L^6]$$

$= [ML^5T^{-2}]$

14. (a) $[a] = [T^2]$ and $[b] = \frac{[a-t^2]}{[P][x]} = \frac{T^2}{[ML^{-1}T^{-2}][L]}$

$\Rightarrow [b] = [M^{-1}T^4]$

So $\left[\frac{a}{b}\right] = \frac{[T^2]}{[M^{-1}T^4]} = [MT^{-2}]$

15. (d) $C = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \Rightarrow \frac{1}{\mu_0\varepsilon_0} = c^2 = [L^2T^{-2}]$

16. (a) $[e] = [AT]$, $\in_0 = [M^{-1}L^{-3}T^4A^2]$, $[h] = [ML^2T^{-1}]$ and $[c] = [LT^{-1}]$

$$\therefore \left[\frac{e^2}{4\pi\in_0 hc}\right] = \left[\frac{A^2T^2}{M^{-1}L^{-3}T^4A^2\times ML^2T^{-1}\times LT^{-1}}\right]$$

$= [M^0L^0T^0]$

17. (c) Volume of sphere $(V) = \frac{4}{3}\pi r^3$

% error in volume $= 3\times\frac{\Delta r}{r}\times 100 = \left(3\times\frac{0.1}{5.3}\right)\times 100$

18. (d) $P = \frac{F}{A} = \frac{F}{l^2}$, so maximum error in pressure (P)

$$\left(\frac{\Delta P}{P}\times 100\right)_{max} = \frac{\Delta F}{F}\times 100 + 2\frac{\Delta l}{l}\times 100$$

=4%+2×2%=8%

19. (c) Percentage error in g = (%error in l) + 2(% error in T) = 1% + 2(3%) = 7%

20. (b) Volume $V = l\times b\times t$

$= 12\times 6\times 2.45 = 176.4\ cm^3$

$V = 1.764\times 10^2\ cm^3$

since, the minimum number of significant figure is one in breadth, hence volume will also contain only one significant figure. Hence, $V = 2\times 10^2\ cm^3$.