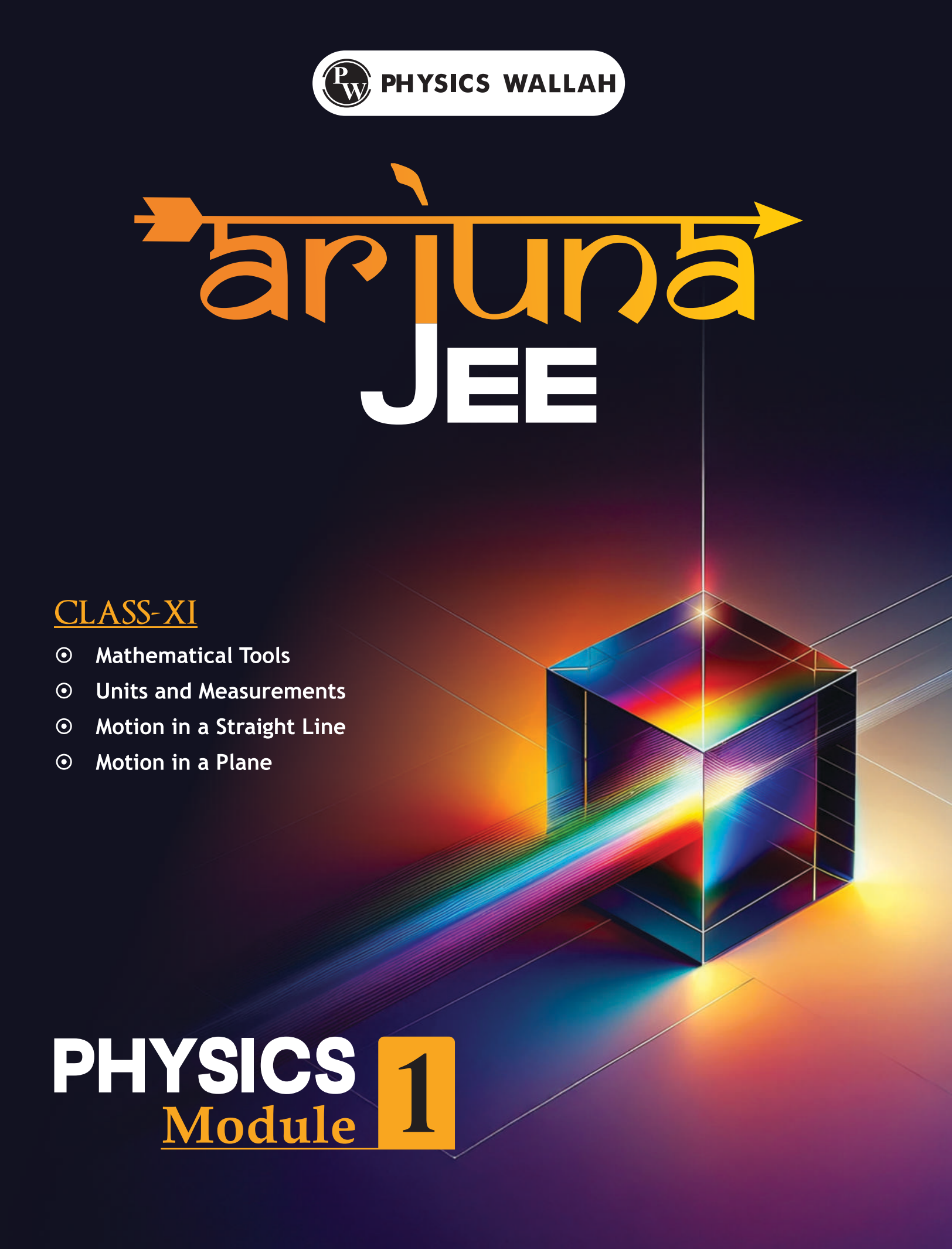
PHYSICS WALLAH

# arjuna JEE

## CLASS-XI

- Mathematical Tools
- Units and Measurements
- Motion in a Straight Line
- Motion in a Plane



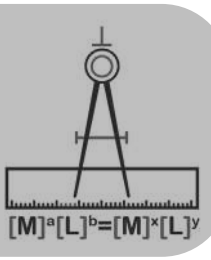
# PHYSICS 1

## Module

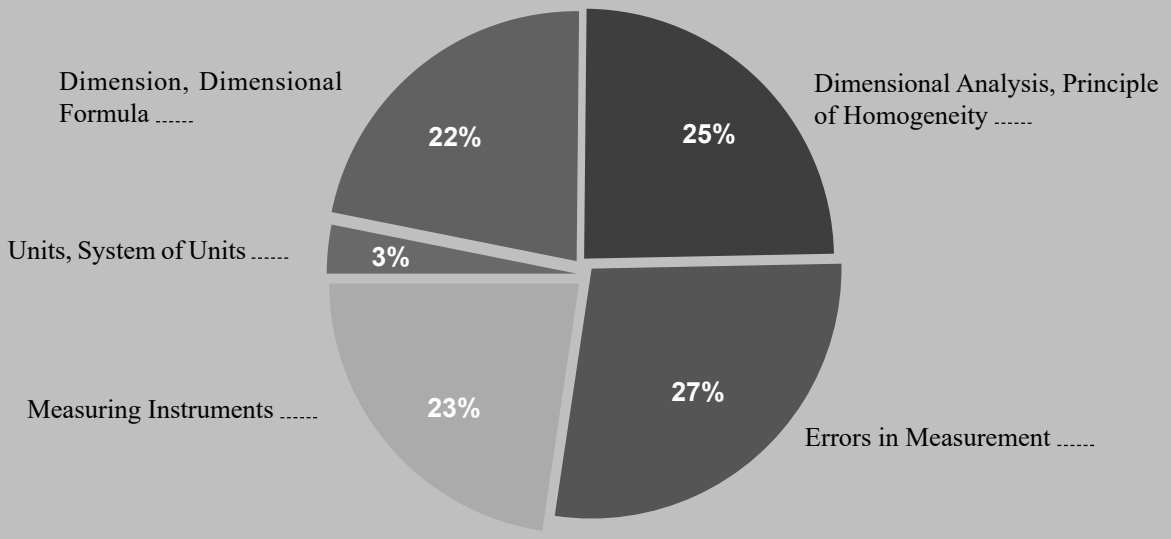
CHAPTER

# 2

# Units and Measurements




## Topicwise Weightage of JEE Main 6 Years Paper (124 Sets)




**"How's the Josh?" for these Topics:** *Mark your confidence level in the blank space around the topic (Low-L, Medium-M, High-H)*

## PHYSICAL QUANTITIES

All quantities that can be measured are called physical quantities. e.g. time, length, mass, force, work done, etc. In physics we study about physical quantities and their inter relationships.

### Fundamental Quantities

A set of physical quantities which are completely independent of each other but all other physical quantities can be expressed in terms of these physical quantities is called set of Fundamental Quantities.

The Fundamental Quantities that are currently being accepted by the scientific community are mass, time, length, current, temperature, luminous intensity and amount of substance.

### Derived Physical Quantities

The physical quantities that can be expressed in terms of fundamental physical quantities are called derived physical quantities. E.g. speed = distance/time.

## MEASUREMENT

Measurement is the comparison of a quantity with a standard of the same physical quantity. In the past different countries followed different standards.

## UNITS

All physical quantities are measured with respect to standard magnitude of the same physical quantity and these standards are called UNITS. e.g. second, meter, kilogram, etc.

**Four basic properties of units are:**

1. They must be well defined.
2. They should be easily available and reproducible.
3. They should be invariable e.g. step as a unit of length is not invariable.
4. They should be accepted to all.

## SYSTEM OF UNITS

1. **FPS or British Engineering system:** In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.
2. **CGS or Gaussian system:** In this system the fundamental quantities are length, mass and time and their respective units are centimetre (cm), gram (g) and second (s).
3. **MKS system:** In this system also the fundamental quantities are length, mass and time but their fundamental units are meter (m), kilogram (kg) and second (s) respectively.

Now writing the dimension of each quantity on either side.

$[ML^{-1}T^{-2}] = K\,[MLT^{-2}]^x\,[L^2]^y\,[ML^{-3}]^z$

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

Now comparing the powers

For M, $1 = x + z$ ...(i)

L, $-1 = x + 2y - 3z$ ...(ii)

T, $-2 = -2x$ ...(iii)

$\Rightarrow$ Solving we get, $x = 1, y = -1, z = 0$

$\therefore\ P = KwA^{-1}\rho^0$

## Concept Application

**7.** If $c$ is the velocity of light, $h$ is Planck's constant and $G$ is Gravitational constant are taken as fundamental quantities, then the dimensional formula of mass is

**8.** Taking frequency $f$, velocity ($v$) and Density ($\rho$) to be the fundamental quantities then the dimensional formula for momentum will be

($a$) $(\rho v^4 f^{-3})$ ($b$) $(\rho v^3 f^{-1})$

($c$) $(\rho v f^2)$ ($d$) $(\rho^2 v^2 f^2)$

**9.** If momentum (P), mass (M) and time (T) are chosen as fundamental quantities the dimensional formula for length is _____.

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

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

**10.** For the equation $F = A^a v^b d^c$ where $F$ is force, A is area, $v$ is velocity and $d$ is density, with the dimensional analysis gives the following values for exponents.

($a$) $a = 1, b = 2, c = 1$

($b$) $a = 2, b = 1, c = 1$

($c$) $a = 1, b = 1, c = 2$

($d$) $a = 0, b = 1, c = 1$

## Conversion From One System of Units to Other

It is based on the fact that,

Numerical value × unit = constant

So on changing unit, numerical value will also change. If $n_1$ and $n_2$ are the numerical values of a given physical quantity and $u_1$ and $u_2$ be the units respectively in two different systems of units, then

$n_1u_1 = n_2u_2$

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

## LIMITATIONS OF DIMENSIONAL ANALYSIS

($i$) It supplies no information about dimensionless constants and the nature (vector and scalar) of physical quantities.

($ii$) This method is applicable only if relation is of product type. It fails in the case of exponential and trigonometric relations.

($iii$) It does not predict numerical correctness of formula.

## Train Your Brain

**Example 13:** Convert 1 newton (SI unit of force) into dyne (CGS unit of force)

**Sol.** The dimensional equation of force is $[F] = [M^1\,L^1T^{-2}]$

Therefore if $n_1$, $u_1$ and $n_2$, $u_2$ corresponds to SI and CGS numerical value and unit respectively, then

$$n_2 = n_1\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 1\left[\frac{kg}{g}\right]\left[\frac{m}{cm}\right]\left[\frac{s}{s}\right]^{-2} = 1\times(1000)(100)(1) = 10^5$$

**Example 14:** A calorie is a unit of heat or energy and it equals about 4.2 J, where 1 J = 1 kg $m^2/s^2$. Suppose we employ a system of units in which the unit of mass equals $\alpha$ kg, the unit of length equals $\beta$ metre, the unit of time is $\gamma$ second. Show that a calorie has a magnitude 4.2 $\alpha^{-1}\beta^{-2}\gamma^2$ in terms of the new units.

**Sol.** 1 cal = 4.2 kg $m^2s^{-2}$

| **SI** | **New system** |
|---|---|
| $n_1 = 4.2$ | $n_2 = ?$ |
| $M_1 = 1$ kg | $M_2 = \alpha$ kg |
| $L_1 = 1$ m | $L_2 = \beta$ metre |
| $T_1 = 1$ s | $T_2 = \gamma$ second |

Dimensional formula of energy is $[ML^2T^{-2}]$

Comparing with $[M^aL^bT^c]$,

We find that $a = 1, b = 2, c = -2$

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

$$= 4.2\left[\frac{1\text{ kg}}{\alpha\text{ kg}}\right]^1\left[\frac{1\text{ m}}{\beta\text{ m}}\right]^2\left[\frac{1\text{ s}}{\gamma\text{ s}}\right]^{-2} = 4.2\ \alpha^{-1}\beta^{-2}\gamma^2$$

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

**Sol.** The unit of Young's modulus is $N/m^2$.

This suggest that it has dimensions of $\frac{\text{Force}}{(\text{Distance})^2}$.

Thus, $$[Y] = \left[\frac{F}{L^2}\right] = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}].$$

**1.** $\int \frac{xdx}{\sqrt{2ax-x^2}} = a^n \sin^{-1}\left[\frac{x}{a}-1\right]$. The value of $n$ is

($a$) 0 ($b$) –1

($c$) 1 ($d$) None of these

Use dimensional analysis to solve the problem.

**Sol.** $\int \frac{x\,dx}{\sqrt{2ax-x^2}} = a^n \sin^{-1}\left[\frac{x}{a}-1\right]$

Denominator $2ax - x^2$ must have the dimension of $[x]^2$

($\because$ we can add or subtract only if quantities have same dimension

$\therefore \left[\sqrt{2ax-x^2}\right] = [x]$

Also, $dx$ has the dimension of $[x]$

$\therefore \frac{x\ dx}{\sqrt{2ax-x^2}}$ is having dimension L

Equating the dimension of L.H.S. and R.H.S. we have

$[a^n] = M^0L^1T^0$

$\{\because \sin^{-1}\left(\frac{x}{a}-1\right)$ must be dimensionless$\}$

Therefore, option ($c$) is the correct answer.

**2.** In the formula; $P = \frac{nRT}{V-b}\ e^{-\frac{a}{RTV}}$ find the dimensions of '$b$' and '$a$' respectively, where $P$ = pressure, $n$ = no. of moles, $T$ = temperature, $V$ = volume and $R$ = universal gas constant.

($a$) $[L^3]$, $[MLT^{-2}]$ ($b$) $[M^2L]$, $[ML^5T^{-2}]$

($c$) $[L^3]$, $[ML^5T^{-2}mol^{-1}]$ ($d$) $[M^2L]$, $[MLT^{-2}]$

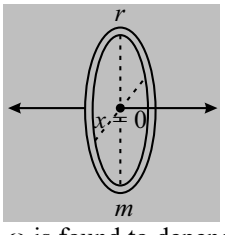
**Sol.** $[b] = [V] = [L^3]$

$[a] = [RTV] = \frac{[PV]}{[n]}[V] = \frac{ML^2T^{-2}L^3}{mol}$ ($\because nRT = PV$)

$= ML^5T^{-2}mol^{-1}$.

Therefore, option ($c$) is the correct answer.

**3.** A particle is performing SHM along the axis of a fixed ring. Due to gravitational force, its displacement at time $t$ is given by $x = a\sin\omega t$.




In this equation ω is found to depend on radius of the ring ($r$), mass of the ring ($m$) and gravitational constant ($G$).

Using dimensional analysis, find the expression of ω in terms of $m$, $r$ and $G$.

($a$) $\sqrt{\frac{Gm}{r}}$ ($b$) $\sqrt{\frac{Gm}{r^3}}$ ($c$) $\sqrt{\frac{G}{mr^2}}$ ($d$) $\sqrt{\frac{Gr^3}{m}}$

**Sol.** Let $\omega = Km^ar^bG^c$ where $K$ is a dimensionless constant

Writing the dimension of both the sides and equating them we have,

$T^{-1} = M^aL^b(M^{-1}L^3T^{-2})^c$

$= M^{a-c}L^{b+3c}T^{-2c}$

Equating the exponents,

$-2c = -1$ or $c = 1/2$;

$b + 3c = 0$ or $-3c = b = -\frac{3}{2}$;

$a - c = 0$, $c = a = +\frac{1}{2}$

Thus the required equation is $\omega = K\sqrt{\frac{Gm}{r^3}}$.

Therefore, option ($b$) is the correct answer.

**4.** Using screw gauge, the observation of the diameter of a wire are 1.324, 1.326, 1.334, 1.336 cm respectively. The value of diameter of wire along with its percentage uncertainty will be

($a$) $1.33 \pm 1\%$ ($b$) $1.30 \pm 0.4\%$

($c$) $1.30 \pm 1\%$ ($d$) $1.33 \pm 0.4\%$

**Sol.** Average diameter:

$\bar{D} = \frac{\Sigma(D)}{N} = \frac{1.324+1.326+1.334+1.336}{4} = 1.330$

$\Delta D_1 = 1.324 - 1.330 = -0.006$

$\Delta D_2 = 1.326 - 1.330 = -0.004$

$\Delta D_3 = 1.334 - 1.330 = 0.004$

$\Delta D_4 = 1.336 - 1.330 = 0.006$

Mean absolute error:

$\overline{\Delta D} = \frac{|\Delta D_1| + |\Delta D_2| + |\Delta D_3| + |\Delta D_4|}{4}$

$= \frac{0.006+0.004+0.004+0.006}{4} = \frac{0.020}{4} = 0.005\,cm$

Relative error $= \frac{\Delta\bar{D}}{D} = \frac{0.005}{1.330} = 0.004$

% error $= \frac{\Delta\bar{D}}{D} \times 100 = 0.4\%$

Therefore, option ($d$) is the correct answer.

**5.** If a tuning fork of frequency ($f_0$) 340 Hz and tolerance 1% is used in resonance column method [$v = 2f_0(\ell_2 - \ell_1)$], the first and the second resonance are measured at $\ell_1 = 24.0$ cm and $\ell_2 = 74.0$ cm. Find maximum permissible error in speed of sound.

($a$) 1.4% ($b$) 2.8% ($c$) 0.5% ($d$) 0.7%

**Sol.** $v = 2f_0(\ell_2 - \ell_1)$

$\Rightarrow \left(\frac{\Delta v}{v}\right)_{max} = \frac{\Delta f_0}{f_0} + \frac{\Delta\ell_1 + \Delta\ell_2}{\ell_2 - \ell_1} = \frac{1}{100} + \frac{0.1+0.1}{74-24} = 1.4\%$

Therefore, option ($a$) is the correct answer.

# School Level Problems

## SINGLE CORRECT TYPE QUESTIONS

**1.** Which among the following is the supplementary unit———

(*a*) Mass (*b*) Time

(*c*) Solid angle (*d*) Luminosity

**2.** The number of significant digits in 1559.00 is_____

(*a*) 6 (*b*) 5 (*c*) 3 (*d*) 4

**3.** Joule second is the unit of

(*a*) Force (*b*) Angular momentum

(*c*) Energy (*d*) Power

**4.** What is the number 75.66852 rounded off to 5 significant digits?

(*a*) 75.67 (*b*) 75.669

(*c*) 75.668 (*d*) 75.667

**5.** The division of energy by time is *X*. The dimensional formula of *X* is same as that of

(*a*) power (*b*) electric field

(*c*) momentum (*d*) torque

**6.** 1 kWh =

(*a*) 1000 W (*b*) $36 \times 10^5$ J

(*c*) 1000 J (*d*) 3600 J

**7.** Density of wood is 0.5 gm/cc in the CGS system of units. The corresponding value in MKS units is:

(*a*) 500 (*b*) 5

(*c*) 0.5 (*d*) 5000

**8.** Which of the following is a derived unit?

(*a*) Unit of mass (*b*) Unit of area

(*c*) Unit of time (*d*) Unit of current

**9.** Newton/meter$^2$ is the unit of:

(*a*) Energy (*b*) Momentum

(*c*) Force (*d*) Pressure

**10.** Dimensional formula of heat energy is

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

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

**11.** **Assertion:** If the units of force and length are doubled, the unit of energy will become four times.

**Reason:** The unit of energy is independent of the units of force and length.

(*a*) Assertion and reason both are true and reason is correct explanation for assertion.

(*b*) Assertion and reason both are true but reason is not correct explanation for assertion.

(*c*) Assertion is true but reason is false.

(*d*) Assertion is false but reason is true.

**12.** **Assertion:** Dimensional constants are the quantities whose values are constant.

**Reason:** Dimensional constants are dimensionless.

(*a*) Assertion and reason both are true and reason is correct explanation for assertion.

(*b*) Assertion and reason both are true but reason is not correct explanation for assertion.

(*c*) Assertion is true but reason is false.

(*d*) Assertion is false but reason is true.

## VERY SHORT ANSWER TYPE QUESTIONS

**13.** What is the number of significant figures in 0.06070?

**14.** If $x = a + bt + ct^2$, where $x$ is in meter and $t$ in seconds, what is the unit of c?

**15.** Will the dimensions of a physical quantity be the same, whatever be the units in which it is measured? Why?

**16.** What do you mean by the term measurement?

**17.** Define dimensions of a physical quantity.

**18.** S.I units are coherent. Explain.

**19.** What are the limitations of dimensional analysis? (Any two)

## SHORT ANSWER TYPE QUESTIONS

**20.** 5.74 g of a substance occupies 1.2 cm$^3$. Express its density to correct significant figures.

**21.** Derive the dimensional formula of:

(*a*) Angular velocity

(*b*) Angular momentum

## LONG ANSWER TYPE QUESTIONS

**22.** The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm, respectively. Give the area and volume of the sheet to correct significant figures.

**23.** The frequency of vibration of a string depends on, (i) tension in the string (ii) mass per unit length of string, (iii) vibrating length of the string. Establish dimensionally the relation for frequency.

## CASE STUDY BASED QUESTIONS

**24.** The nature of physical quantity is described by its dimension. All the physical quantities can be expressed in terms of some combination of seven fundamental units. The dimensions of a physical quantity are thus the powers to which the base quantities are raised to represent that quantity.

If a given physical quantity depends on $a^{th}$ power of mass, $b^{th}$ power of length, $c^{th}$ power of time etc., then its dimensions are expressed as $[M^a L^b T^c]$.

(*i*) The dimension of planck's constant equal to that of

(*a*) Energy (*b*) Momentum

(*c*) angular momentum (*d*) power

(*ii*) If force (F), velocity (V) and time (T) are taken as fundamental units, then dimension of mass are

(*a*) $[FVT^{-2}]$ (*b*) $[FV^{-1}T^{-1}]$

(*c*) $[FV^{-1}T]$ (*d*) $[FVT^{-1}]$

(*iii*) Which of the following sets have different dimensions

(*a*) Pressure and Young's modulus

(*b*) Emf and potential difference

(*c*) Heat and work done

(*d*) Dipole moment and electric flux

(*iv*) The dimension of a × b in the relations:-

$P = \frac{b - x^2}{at}$, where P is power, x is distance and t is time.

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

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

(*v*) Find the value of 100 J on a system which has 20 cm, 250 g and half minute as fundamental units of length, mass and time.

(*a*) $9 \times 10^{-6}$ new units (*b*) $2.16 \times 10^6$ new units

(*c*) $9 \times 10^6$ new units (*d*) 100 new units

**25.** The Vander Waal's equation is $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

Where P is pressure, V is volume, T is absolute temperature of given sample of a gas, R is called molar gas constant, *a* and *b* are Vander waal's constant.

Now answer the following

(*i*) The dimensional formula for b is same as for

(*a*) V (*b*) $PV^2$ (*c*) RT (*d*) P

(*ii*) The dimensional formula for a is same as for

(*a*) $V^2$ (*b*) P (*c*) $PV^2$ (*d*) RT

(*iii*) The dimensional formula of $\frac{ab}{RT}$ is

(*a*) $[ML^5T^{-2}]$ (*b*) $[M^0L^3T^0]$

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

(*iv*) The dimensional formula for RT is same as for

(*a*) Energy (*b*) force

(*c*) Latent heat (*d*) Specific heat

(*v*) The dimensional formula for RT is not same as that for

(*a*) $\frac{ab}{V^2}$ (*b*) Pb

(*c*) $\frac{a}{V^2}$ (*d*) PV

# Prarambh (Topicwise)

## UNITS, SYSTEM OF UNITS

**1.** Which of the following is not the unit of time?

(*a*) Solar day (*b*) Parallactic second

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

**2.** A unitless quantity

(*a*) Never has a non zero dimension

(*b*) Always has a non zero dimension

(*c*) May have a non zero dimension

(*d*) Does not exit

**3.** Which of the following is not the name of a physical quantity?

(*a*) Kilogram (*b*) Impulse

(*c*) Energy (*d*) Density

**4.** Parsec is a unit of

(*a*) Time (*b*) Angle

(*c*) Distance (*d*) Velocity

**5.** Which of the following system of units is not based on the unit of mass, length and time alone?

(*a*) FPS (*b*) SI

(*c*) CGS (*d*) MKS

**6.** In the S.I. system the unit of energy is:

(*a*) Erg (*b*) Calorie

(*c*) Joule (*d*) Electron volt

**7.** The SI unit of the universal gravitational constant *G* is

(*a*) N m $kg^{-2}$ (*b*) N $m^2$ $kg^{-2}$

(*c*) N $m^2$ $kg^{-1}$ (*d*) N m $kg^{-1}$

**8.** Surface tension has unit of

(*a*) Joule $m^2$ (*b*) Joule $m^{-2}$

(*c*) Joule $m^{-1}$ (*d*) Joule $m^3$

**9.** The specific resistance has the unit of:

(*a*) ohm/m (*b*) ohm/$m^2$

(*c*) ohm $m^2$ (*d*) ohm m

**10.** The unit of magnetic moment is:

(*a*) Amp $m^2$ (*b*) Amp $m^{-2}$

(*c*) Amp m (*d*) Amp $m^{-1}$

**11.** The SI unit of the universal gas constant *R* is

(*a*) Erg $K^{-1}$ $mol^{-1}$ (*b*) Watt $K^{-1}$ $mol^{-1}$

(*c*) Newton $K^{-1}$ $mol^{-1}$ (*d*) Joule $K^{-1}$ $mol^{-1}$

**12.** The SI unit of Stefan's constant is

(*a*) $Ws^{-1}$ $m^{-2}$ $K^{-4}$ (*b*) J $s^{-1}$ $m^{-1}$ $K^{-1}$

(*c*) J $s^{-1}$ $m^{-2}$ $K^{-1}$ (*d*) W $m^{-2}$ $K^{-4}$

## MEASURING INSTRUMENTS

**57.** In a vernier callipers, ten divisions of the vernier scale is equal to the length of nine division on the main scale. If the smallest division on the main scale is half millimeter, then the vernier constant is:

(*a*) 0.5 mm (*b*) 0.1 mm

(*c*) 0.05 mm (*d*) 0.005 mm

**58.** A vernier callipers has 20 divisions on the vernier scale, which coincide with 19 divisions on the main scale. The least count of the instrument is 0.1 mm. The main scale divisions are of

(*a*) 0.5 mm (*b*) 1 mm

(*c*) 2 mm (*d*) 1/4 mm

**59.** A vernier callipers having 1 main scale division = 0.1 cm is designed to have a least count of 0.02 cm. If *n* be the number of divisions on vernier scale and *m* be the length of vernier scale, then

(*a*) $n = 10, m = 0.5$ cm (*b*) $n = 9, m = 0.4$ cm

(*c*) $n = 10, m = 0.8$ cm (*d*) $n = 10, m = 0.2$ cm

**60.** The pitch of a screw gauge is 0.05 cm. In how many revolutions of hollow cylinder the screw will advance 0.35 cm in the straight line?

(*a*) 7 (*b*) 10 (*c*) 15 (*d*) 14

**61.** A student in the laboratory measures thickness of a wire using screw gauge. The readings are 1.22 mm, 1.23 mm, 1.19 mm, 1.20 mm. The percentage error in measurement.

(*a*) 2.20% (*b*) 1.24% (*c*) 2.85% (*d*) 3.52%

# Prabal (JEE Main Level)

**1.** The unit of impulse is the same as that of

(*a*) Moment of force

(*b*) Linear momentum

(*c*) Rate of change of linear momentum

(*d*) Force

**2.** Which of the following is not the unit of energy?

(*a*) Watt-hour (*b*) Electron-volt

(*c*) N × m (*d*) kg × m/sec$^2$

**3.** If *a* and *b* are two physical quantities having different dimensions then which of the following can denote a new physical quantity?

(*a*) $a + b$ (*b*) $a - b$

(*c*) $a/b$ (*d*) $e^{a/b}$

**4.** The time dependence of a physical quantity $P = P_0 \exp(-\alpha t^2)$ where $\alpha$ is a constant and *t* is time The constant $\alpha$

(*a*) will be dimensionless

(*b*) will have dimensions of $T^{-2}$

(*c*) will have dimensions as that of *P*

(*d*) will have dimensions equal to the dimension of *P* multiplied by $T^{-2}$

**5.** Which pair of following quantities has dimensions different from each other?

(*a*) Impulse and linear momentum

(*b*) Plank's constant and angular momentum

(*c*) Moment of inertia and moment of force

(*d*) Young's modulus and pressure

**6.** The product of energy and time is called action. The dimensional formula for action is same as that for

(*a*) Power (*b*) Angular energy

(*c*) Force × velocity (*d*) Impulse × distance

**7.** What is the physical quantity whose dimensions are $[M L^2 T^{-2}]$?

(*a*) Kinetic energy (*b*) Pressure

(*c*) Momentum (*d*) Power

**8.** If *E*, *M*, *J* and *G* denote energy, mass, angular momentum and gravitational constant respectively, then $\frac{EJ^2}{M^5G^2}$ has the dimensions of

(*a*) Length (*b*) Angle

(*c*) Mass (*d*) Time

**9.** The position of a particle at time '*t*' is given by the relation $x(t) = \frac{V_0}{\alpha}[1 - e^{-\alpha t}]$ where $V_0$ is a constant and $\alpha > 0$. The dimensions of $V_0$ and $\alpha$ are respectively.

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

(*c*) $M^0L^1T^{-1}$ and $T^{-1}$ (*d*) $M^0L^1T^{-1}$ and $T^{-2}$

**10.** If force (*F*) is given by $F = Pt^{-1} + \alpha t$, where *t* is time. The unit of *P* is same as that of

(*a*) Velocity (*b*) Displacement

(*c*) Acceleration (*d*) Momentum

**11.** When a wave traverses a medium, the displacement of a particle located at *x* at time *t* is given by $y = a\sin(bt - cx)$ where *a*, *b* and *c* are constants of the wave. The dimensions of *b* are the same as those of

(*a*) Wave velocity (*b*) Amplitude

(*c*) Wavelength (*d*) Wave frequency

**12.** In a book, the answer for a particular question is expressed as $b = \frac{ma}{k}\left[\sqrt{1 + \frac{2kl}{ma}}\right]$ here *m* represents mass, *a* represents accelerations, *l* represents length. The unit of *b* should be

(*a*) m/s (*b*) m/s$^2$

(*c*) meter (*d*) /sec

## MULTIPLE CORRECT TYPE QUESTIONS

**1.** Choose the correct statement(s).
(*a*) All quantities may be represented dimensionally in terms of the base quantities.
(*b*) A base quantity cannot be represented dimensionally in terms of the rest of the base quantities.
(*c*) The dimension of a base quantity in other base quantities is always zero.
(*d*) The dimension of a derived quantity is never zero in any base quantity.

**2.** The dimensions $[ML^{-1}T^{-2}]$ may correspond to
(*a*) Work done by a force
(*b*) Linear momentum
(*c*) Pressure
(*d*) Energy per unit volume

**3.** A student curiously picks up Resnick and Halliday and tries to understand the answers given at the end of the book using his new found knowledge of physics. He marks four answers. In which of the following quantity $A$ has the same units as that of angular momentum ?

Useful formula, $\vec{L} = \vec{r} \times \vec{p}$, $\omega = \frac{2\pi}{T}$, $\vec{\tau} = \vec{r} \times \vec{F}$, $E$ represent energy, $l$ represents length $c$ represents velocity of light, $f$ represents frequency and $t$ represents time.

(*a*) $\frac{1}{2}mv^2 = Af$ (*b*) $\Delta p = \frac{2A\omega}{v}\sqrt{1-\frac{v^2}{c^2}}$

(*c*) $\sin(kl) = k\sqrt{\frac{A^2}{2mE}}$ (*d*) $t = Al$

**4.** The quantity/quantities that does/do not have mass in its/their dimensions (when we take standard 7 quantities as fundamental) is/are
(*a*) Specific heat (*b*) Latent heat
(*c*) Luminous intensity (*d*) Mole

**5.** The power output for a hovering helicopter depends on its linear size, the density of air and g × density of the helicopter as $P \propto$ (linear size)$^x$ (density of air)$^y$ ($g$ × density of helicopter)$^z$ where $g$ is acceleration due to gravity.
[Given: [Power] = $[ML^2T^{-3}]$, [Linear size] = [L], [Density] = $[ML^{-3}]$, [$g$ × density] = $[ML^{-2}T^{-2}]$]
(*a*) The value of $y$ is –1/2.
(*b*) The ratio of power output of engines of two hovering helicopters when linear size of one helicopter is one fourth of the other keeping all other parameters same, is 64.
(*c*) The ratio of the power output to hover a helicopter on the earth and on an imaginary planet, where $g_{planet} = g/4$ and density of air on imaginary planet is same as that of earth, is 8.
(*d*) If helicopter is to hover at higher altitudes then we need less powerful engine.

**6.** A student taking a quiz finds on a reference sheet the two equations $\nu = 1/T$ and $v = \sqrt{T/\mu}$
($\mu$ = mass/length, torque = $\vec{r} \times \vec{F}$ and rest of symbols have usual notations.)
He has forgotten what $T$ represents in each equation. Use dimensional analysis to determine the units of $T$ in each equation.
(*a*) In first equation $T$ represents tension.
(*b*) In first equation $T$ represents time.
(*c*) In second equation $T$ represents torque.
(*d*) In second equation $T$ represents tension.

**7.** A chunk of unknown rock has mass 38.254 ± 0.003 grams and has a volume of 15.0 cm$^3$.
(*a*) The density of the rock is 2.55 g/cm$^3$.
(*b*) The absolute error in density is 0.02 g/cm$^3$.
(*c*) The relative error in density is 0.007.
(*d*) The number of significant figure 3 in density are 3.

**8.** Using a screw gauge the diameter of a wire is found to be 5.00 mm. The length of wire is measured by using a scale and is found to be 50.0 cm. If mass of wire is measured as 25 g, then mark the correct statement(s) (Take $\pi$ = 3.14).
(*a*) The density has to be computed upto 2 significant digits.
(*b*) The least count of scale used to measure length of wire is 1 mm.
(*c*) The density of wire is 2.6 g/cm$^3$
(*d*) The least count of screw gauge is 0.01 mm

## COMPREHENSION BASED QUESTIONS

**Comprehension (Q. 9 to 11):** Let us consider a particle $P$ which is moving straight on the $X$-axis. We also know that the rate of change of its position is given by $\frac{dx}{dt}$; where $x$ is its separation from the origin and $t$ is time. This term $\frac{dx}{dt}$ is called the velocity of particle ($v$). Further the second derivation of $x$ with respect to time is called acceleration ($a$) or rate of change of velocity and is represented by $\frac{d^2x}{dt^2}$ or $\frac{dv}{dt}$. If the acceleration of this particle is found to depend upon time as follows $a = At + Bt^2 + \frac{Ct}{D+t^2}$ then

**9.** The dimensions of $A$ are
(*a*) $LT^{-2}$ (*b*) $LT^{-3}$ (*c*) $LT^3$ (*d*) $L^2T^3$

**10.** The dimensions of $B$ are
(*a*) $LT^{-4}$ (*b*) $L^2T^{-3}$ (*c*) $LT^4$ (*d*) $LT^{-2}$

**11.** The dimensions of $C$ are
(*a*) $L^2T^{-2}$ (*b*) $LT^{-2}$ (*c*) $LT^{-1}$ (*d*) $T^2$

## UNITS, SYSTEM OF UNITS

**1.** Electric field in a certain region is given by $\vec{E}=\left(\frac{A}{x^2}\hat{i}+\frac{B}{y^3}\hat{j}\right)$. The SI unit of $A$ and $B$ are: **[30 Jan, 2023 (Shift-I)]**

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

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

(*c*) $Nm^3C; Nm^2C$

(*d*) $Nm^2C; Nm^3C$

**2.** Match List-I with List-II. **[27 Aug, 2021 (Shift-II)]**

| List-I | | List-II | |
|---|---|---|---|
| A. | $R_H$ (Rydberg constant) | I. | kg m$^{-1}$ s$^{-1}$ |
| B. | h(Planck's constant) | II. | kg m$^2$ s$^{-1}$ |
| C. | $\mu_B$ (Magnetic field energy density) | III. | m$^{-1}$ |
| D. | $\eta$ (coefficient of viscocity) | IV. | kg m$^{-1}$ s$^{-2}$ |

(*a*) A-II, B-III, C-IV, D-I (*b*) A-III, B-II, C-I, D-IV

(*c*) A-III, B-II, C-IV, D-I (*d*) A-IV, B-II, C-I, D-III

**3.** If $E$ and $H$ represents the intensity of electric field and magnetising field respectively, then the unit of $E/H$ will be: **[27 Aug, 2021 (Shift-I)]**

(*a*) Joule (*b*) Newton

(*c*) Ohm (*d*) Mho

**4.** A physical quantity $\vec{S}$ is defined as $\vec{S}=(\vec{E}\times\vec{B})/\mu_0$, where $\vec{E}$ is electric field, $\vec{B}$ is magnetic field and $\mu_0$ is the permeability of free space. The dimensions of $\vec{S}$ are the same as the dimensions of which of the following quantity (ies)? **[JEE Adv, 2021]**

(*a*) $\frac{\text{Energy}}{\text{Charge}\times\text{Current}}$ (*b*) $\frac{\text{Force}}{\text{Length}\times\text{Time}}$

(*c*) $\frac{\text{Energy}}{\text{Volume}}$ (*d*) $\frac{\text{Power}}{\text{Area}}$

**5.** The density of a material in SI units is 128 kg m$^{-3}$. In certain units in which the unit of length is 25 cm and the unit of mass 50 g, the numerical value of density of the material is **[10 Jan, 2019 (Shift-I)]**

(*a*) 40 (*b*) 16 (*c*) 640 (*d*) 410

## DIMENSION, FINDING DIMENSIONAL FORMULA

**6.** The dimensional formula of latent heat is: **[09 April, 2024 (Shift-I)]**

(*a*) $[M^0LT^{-2}]$ (*b*) $[MLT^{-2}]$

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

**7.** If $\varepsilon_0$ is the permittivity of free space and $E$ is the electric field, then $\varepsilon_0E^2$ has the dimensions: **[08 April, 2024 (Shift-II)]**

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

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

**8.** Given below are two statements:

**Statement (I):** Dimensions of specific heat is $[L^2T^{-2}K^{-1}]$

**Statement (II):** Dimensions of gas constant is $[ML^2T^{-1}K^{-1}]$

**[06 April, 2024 (Shift-II)]**

(*a*) Statement (I) is incorrect but statement (II) is correct

(*b*) Both statement (I) and statement (II) are incorrect

(*c*) Statement (I) is correct but statement (II) is incorrect

(*d*) Both statement (I) and statement (II) are correct

**9.** Match List-I with List-II

| | List-I | | List-II |
|---|---|---|---|
| A. | Torque | I. | $[M^1L^1T^{-2}A^{-2}]$ |
| B. | Magnetic field | II. | $[L^2A^1]$ |
| C. | Magnetic moment | III. | $[M^1T^{-2}A^{-1}]$ |
| D. | Permeability of free space | IV. | $[M^1L^2T^{-2}]$ |

Choose the correct answer from the options given below: **[06 April, 2024 (Shift-I)]**

(*a*) A-I, B-III, C-II, D-IV (*b*) A-IV, B-III, C-II, D-I

(*c*) A-III, B-I, C-II, D-IV (*d*) A-IV, B-II, C-III, D-I

**10.** What is the dimensional formula of $ab^{-1}$ in the equation $\left(P+\frac{a}{V^2}\right)(V-b)=RT$, where letters have their usual meaning. **[05 April, 2024 (Shift-II)]**

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

(*c*) $[M^{-1}L^5T^3]$ (*d*) $[M^6L^7T^4]$

**11.** If $G$ be the gravitational constant and $u$ be the energy density then which of the following quantity has the dimension as that of $\sqrt{uG}$ : **[05 April, 2024 (Shift-I)]**

(*a*) Pressure gradient per unit mass

(*b*) Force per unit mass

(*c*) Gravitational potential

(*d*) Energy per unit mass

**12.** The dimensional formula of angular impulse is: **[1 Feb, 2024 (Shift-I)]**

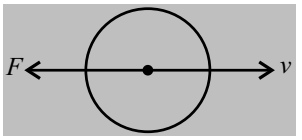
(*a*) $[ML^{-2}T^{-1}]$ (*b*) $[ML^2T^{-2}]$

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

## SINGLE CORRECT TYPE QUESTIONS

**1.** In a certain fluid, measurements indicate that drag force $F$ is proportional to velocity of the object $v$ in power of $\frac{3}{2}$:

$F \propto v^{3/2}$



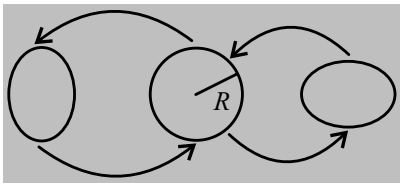

If two spheres of radii $r_1$ and $r_2$ are moving with equal velocity through same fluid they will experience drag force $F_1$ and $F_2$ respectively. If $r_2 = 4r_1$ find $\frac{F_2}{F_1}$.

(The density of fluid is ρ and coefficient of viscosity is η)

(*a*) 2 (*b*) 4

(*c*) 6 (*d*) 8

**2.** A small droplet of water floating at a space station usually has a spherical shape due to surface tension which changes to ellipsoidal shape with some regular time interval $T$




Find ratio $\frac{T_2}{T_1}$ of two period of oscillation $T_1$ and $T_2$ for water droplets with radii $r_1$ and $r_2$ respectively where $r_2 = 2r_1$. Assume no artificial gravity is present at the space station.

(*a*) 2 (*b*) 4

(*c*) $\sqrt{2}$ (*d*) $2\sqrt{2}$

**3.** British physicist G.I Taylor was able to estimate equivalent energy of $E$ of first atomic bomb by looking at pictures that were published in a popular magazine. From the pictures it was clearly established that after time $t = 0.006$s, radius of the cloud was $r \simeq 80$ m. If the density of air $\rho = 1.2$ kg/m$^2$, the energy estimated by Taylor was

(*a*) $10^{14}$ J (*b*) $10^{10}$ J

(*c*) $10^{16}$ J (*d*) $10^{8}$ J

**4.** A certain drone is able to hover if the mechanical power input is $P_1$. If an exact replica is made where all linear dimensions have been doubled, then new power $P_2$ of the mechanical input is

(*a*) $2^{5/2}P_1$ (*b*) $2^{3/2}P_1$

(*c*) $2^{7/2}P_1$ (*d*) $2^{1/2}P_1$

**5.** In cosmology, geometrized system of units (*GU*) is used where we assume

$G = c = 1$

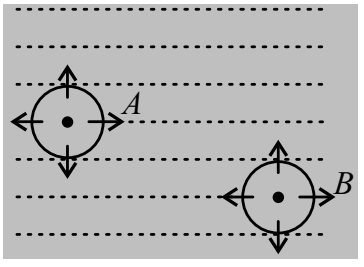
Angular momentum $L_{GU}$ in geometrized units is measured in $m^2$. For conversion between geometrized units and *SI* units for angular momentum we need a conversion factor such that following relation is true $L_{SI} = c^x G^y L_{GU}$

Find the value of $x$ and $y$

(*a*) 3, –1 (*b*) –1, 3

(*c*) 2, –3 (*d*) –2, 3

**6.** Two identical amounts of explosive are burst under water at two different location $A$ and $B$ where hydrostalic pressure are $P_A$ and $P_B$ respectively ($P_B = 1.3\ P_A$). A hollow space occurring due to under water explosion expands and shrinks with some regular period of time $T$ which does not depend on size of the hollow bubble. Assuming that sizes of hollow spaces are much smaller than depths of explosion $A$ and $B$, determine ratio $x$ which is defined as $x = \frac{T_B}{T_A}$ where $T_B$ and $T_A$ are periods of oscillations of two bubbles occurring at location $A$ and $B$ respectively.




(*a*) 0.2 (*b*) 0.5

(*c*) 0.8 (*d*) 0.4

# ANSWER KEY

## CONCEPT APPLICATION

**1.** $[A] = [M^0L^0T^0]$, $[B] = [M^0L^0T^0]$ **2.** $[A] = [L^{1/2}T^{-3}]$, $[B] = [LT^{-3}]$ **3.** $[A] = [L]$, $[B] = M^0L^0T^2$, $[C] = [M^0L^0T^0]$

**4.** $[L^2\ T^{-1}]$ **5.** (*c*) **6.** (*d*) **7.** $m = Kc^{\frac{1}{2}}h^{\frac{1}{2}}G^{-\frac{1}{2}}$ **8.** (*a*) **9.** (*c*) **10.** (*a*) **11.** (*d*) **12.** (*d*)

**13.** (*a*) **14.** (*d*) **15.** (*d*) **16.** (*c*) **17.** (*b*) **18.** (*d*) **19.** (*c*) **20.** (*d*) **21.** [0.002]

**22.** [1.004 ± 0.001] **23.** (*c*) **24.** (*d*) **25.** (*a*) **26.** (*c*) **27.** [1] **28.** (*b*) **29.** [0.005] **30.** [0.215]

**31.** (*a*)

## SCHOOL LEVEL PROBLEMS

**1.** (*c*) **2.** (*a*) **3.** (*b*) **4.** (*c*) **5.** (*a*) **6.** (*b*) **7.** (*a*) **8.** (*b*) **9.** (*d*) **10.** (*a*)

**11.** (*c*) **12.** (*c*) **24.** (*i*) (*c*), (*ii*) (*c*), (*iii*) (*d*), (*iv*) (*a*), (*v*) (*c*) **25.** (*i*) (*a*), (*ii*) (*c*), (*iii*) (*d*), (*iv*) (*a*), (*v*) (*c*)

## PRARAMBH (TOPICWISE)

**1.** (*b*) **2.** (*a*) **3.** (*a*) **4.** (*c*) **5.** (*b*) **6.** (*c*) **7.** (*b*) **8.** (*b*) **9.** (*d*) **10.** (*a*)

**11.** (*d*) **12.** (*d*) **13.** (*c*) **14.** (*c*) **15.** (*b*) **16.** (*b*) **17.** (*b*) **18.** (*d*) **19.** (*b*) **20.** (*a*)

**21.** (*c*) **22.** (*c*) **23.** (*c*) **24.** (*a*) **25.** (*b*) **26.** (*a*) **27.** (*c*) **28.** (*a*) **29.** (*d*) **30.** (*b*)

**31.** (*b*) **32.** (*b*) **33.** (*c*) **34.** (*b*) **35.** (*c*) **36.** (*a*) **37.** (*b*) **38.** (*a*) **39.** (*b*) **40.** (*a*)

**41.** (*c*) **42.** (*c*) **43.** (*a*) **44.** (*a*) **45.** (*a*) **46.** (*a*) **47.** (*c*) **48.** (*b*) **49.** (*b*) **50.** (*b*)

**51.** (*c*) **52.** (*c*) **53.** (*a*) **54.** (*a*) **55.** (*b*) **56.** (*b*) **57.** (*c*) **58.** (*c*) **59.** (*c*) **60.** (*a*)

**61.** (*b*)

## PRABAL (JEE MAIN LEVEL)

**1.** (*b*) **2.** (*d*) **3.** (*c*) **4.** (*b*) **5.** (*c*) **6.** (*d*) **7.** (*a*) **8.** (*b*) **9.** (*c*) **10.** (*d*)

**11.** (*d*) **12.** (*c*) **13.** (*d*) **14.** (*d*) **15.** (*d*) **16.** (*a*) **17.** (*c*) **18.** (*c*) **19.** (*d*) **20.** (*c*)

**21.** (*b*) **22.** (*b*) **23.** (*a*) **24.** (*d*) **25.** (*c*) **26.** (*b*) **27.** (*b*) **28.** (*b*) **29.** (*d*) **30.** (*a*)

**31.** (*c*) **32.** (*a*) **33.** (*a*) **34.** (*d*) **35.** (*b*) **36.** (*c*) **37.** (*b*) **38.** (*a*) **39.** (*a*) **40.** (*b*)

**41.** (*c*) **42.** (*a*) **43.** [1] **44.** [3] **45.** [4] **46.** [0] **47.** [9] **48.** [3] **49.** [6] **50.** [6]

## PARIKSHIT (JEE ADVANCED LEVEL)

**1.** (*a,b,c*) **2.** (*c,d*) **3.** (*a,b,c*) **4.** (*a,b,c,d*) **5.** (*a,c*) **6.** (*b,d*) **7.** (*a,b,c,d*) **8.** (*a,b,c,d*) **9.** (*b*) **10.** (*a*)

**11.** (*c*) **12.** (*c*) **13.** (*d*) **14.** (*b*) **15.** (*d*) **16.** (*d*) **17.** (*a*) **18.** (*c*) **19.** (*a*) **20.** (*a*)

**21.** (*a*) **22.** (*c*) **23.** (*c*) **24.** (*c*) **25.** (*a*) **26.** (*b*) **27.** (*d*) **28.** (*c*) **29.** (*a*) **30.** (*c*)

**31.** [2.59] **32.** [92.14] **33.** [0.41] **34.** [1.67] **35.** [0] **36.** [1] **37.** [4] **38.** (1) **39.** (10) **40.** [928]

**41.** (*d*) **42.** (*c*) **43.** (*b*) **44.** (*b*) **45.** (*c*) **46.** (*a*)

## PYQ's (PAST YEAR QUESTIONS)

**1.** (*b*) **2.** (*c*) **3.** (*c*) **4.** (*b,d*) **5.** (*a*) **6.** (*c*) **7.** (*b*) **8.** (*c*) **9.** (*b*) **10.** (*b*)

**11.** (*b*) **12.** (*d*) **13.** (*a*) **14.** (*c*) **15.** (*a*) **16.** (*b*) **17.** (*a*) **18.** (*a*) **19.** (*b*) **20.** (*c*)

**21.** (*b*) **22.** (*a*) **23.** (*a*) **24.** (*b*) **25.** (*a*) **26.** (*a*) **27.** [4] **28.** (*c*) **29.** (*b*) **30.** (*a*)

**31.** (*c*) **32.** (*a,b,d*) **33.** (*c*) **34.** (*b*) **35.** (*d*) **36.** (*c*) **37.** (*b*) **38.** (*c*) **39.** (*b*) **40.** (*c*)

**41.** (*b*) **42.** (*a*) **43.** (*c*) **44.** (*c*) **45.** (*c*) **46.** (*b*) **47.** (*a*) **48.** (*c*) **49.** (*b*) **50.** (*b*)

**51.** (*b*) **52.** (*d*) **53.** (*c*) **54.** (*a*) **55.** (*b*) **56.** (*c*) **57.** (*d*) **58.** (*d*) **59.** (*b*) **60.** (*b*)

**61.** (*b*) **62.** (*a*) **63.** (*b*) **64.** (*b*) **65.** (*c*) **66.** (*c*) **67.** (*b*)

## PW CHALLENGERS

**1.** (*d*) **2.** (*d*) **3.** (*a*) **4.** (*c*) **5.** (*a*) **6.** (*c*) **7.** (*c*) **8.** (*c*) **9.** (*a*) **10.** [78.3 ± 1.9]

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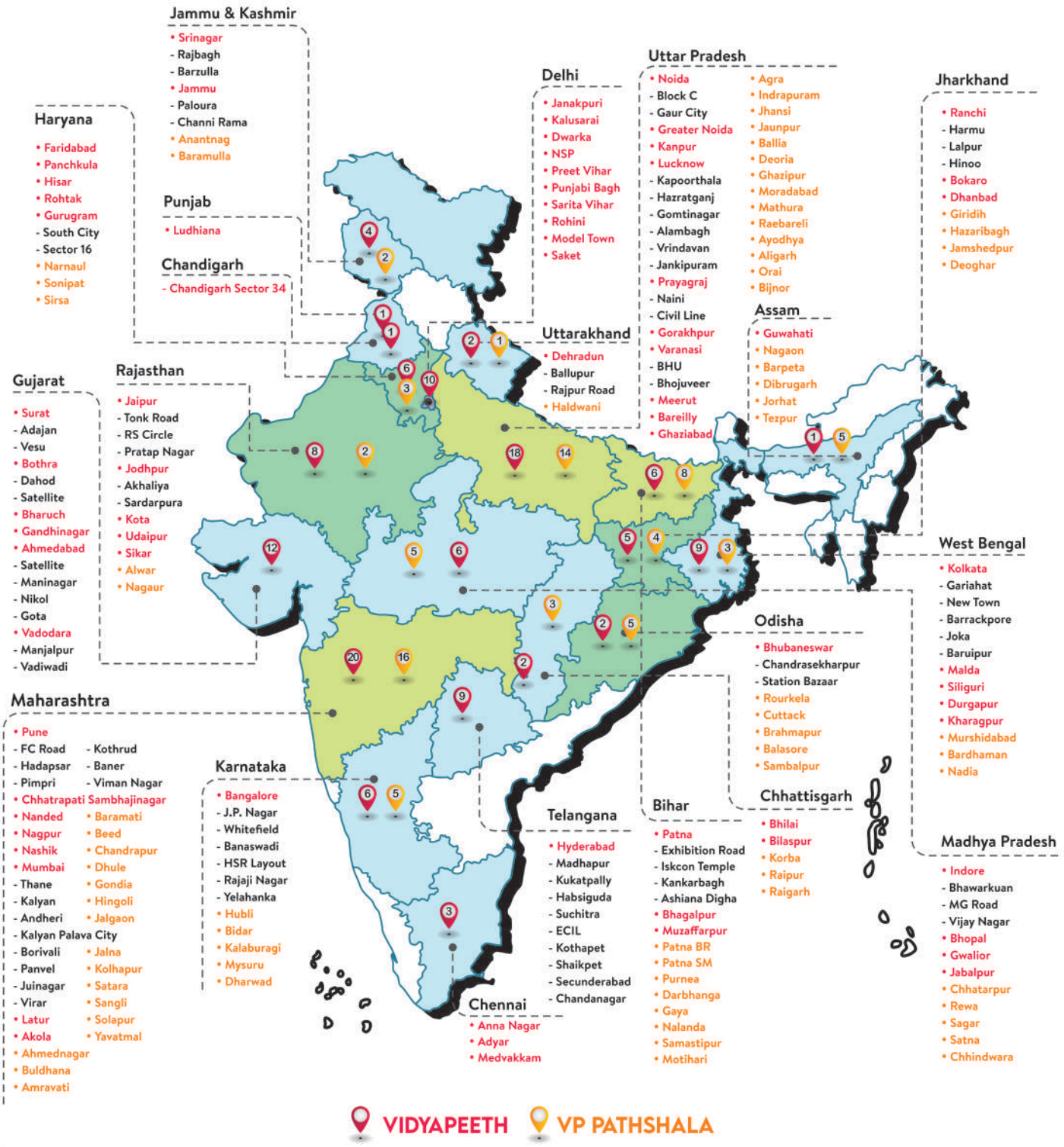


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ISBN 978-93-48141-15-6

SKU Code - bd7b4735-c4ea-41b2-a500-adb07bbe5577