

1

UNITS & MEASUREMENTS

1 OMQ + 1 VSAQ [1 M + 2M = 3 M]

VSAQ (2 Marks)

1×2= 2 Marks

1. What are significant figures and what do they represent when reporting the result of a measurement?

A: **Significant figures** are the 'meaningful digits' in an estimated value which are known to be reliable and certain plus one uncertain (estimated digit).

They express the precision of a measurement.

Ex: Time period of a simple pendulum is 1.62. This measured value has three significant figures. The digits 1 and 6 are reliable while the digit 2 is uncertain.

2. Distinguish between fundamental units and derived units.

[BMP2]

A:

Fundamental Units	Derived Units
1) The units of the fundamental quantities are called fundamental units. Ex: metre, kilogram, second.	1) The units of the derived quantities are called derived units. Ex: ms^{-1} , newton.
2) There are 7 fundamental quantities and hence 7 types of fundamental units exist.	2) There are several derived quantities and hence several derived units exist.

3. What are the two fundamental physical quantities used to measure angle?

A: **Plane angle** in a 2D plane & **Solid angle** in a 3D space.

4. Why do we have different units for the same physical quantity?

[AP 25]

A: A physical quantity possesses a wide range of magnitudes.

Hence, we need different units for different ranges of the same physical quantity.

Ex: Different units for **Mass** : mg, gm, kg etc., ; Different units for **length** : mm, cm, m, km.

☛ Mass ranges from 10^{-30} kg (for an electron) to 10^{53} kg (for the known universe).

5. Define plane angle.

[BMP1]

A: Plane angle is the ratio of length of arc to radius. $\left[\because d\theta = \frac{ds}{r} \text{radian} \right]$ (or)

Plane angle is the angle between two intersecting lines in a two dimensional plane.

6. What is meant by dimension of a physical quantity?

A: **Dimension** of a physical quantity is the power to which the fundamental units must be raised to, in order to represent it.

Ex: Force has 1 dimension in mass M, 1 dimension in length L, and -2 dimension in Time (T).

Thus, Force = $[MLT^{-2}]$

7. What is meant by dimensional formula?

A: **Dimensional formula:** It is the expression in which a physical quantity is expressed with proper dimensions in fundamental quantities.

Ex 1 : D.F of Volume is $[M^0L^3T^0]$

Ex 2 : D.F of Force is $[MLT^{-2}]$

8. Write the physical quantities that are having Jm^{-1} and Jm^{-2} as their units. [MAR-26]

A: **Force** has unit Jm^{-1}

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

Surface tension has unit Jm^{-2}

$[\because ML^2T^{-2} \times L^{-2} = [ML^0T^{-2}] = \text{Surface tension}]$

2

MOTION IN A STRAIGHT LINE

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

1×2= 2 Marks

1. The states of rest and motion are relative. Explain. [MAR-26]

A: For a person travelling in a train, the co-passengers appear to be at rest, but objects outside the train like electric poles, trees etc, appear to be moving backwards.

For a person on the platform the electric poles, trees etc. appear to be at rest but the train appears to be moving. So the states of rest and motion are relative.

2. Is it necessary that the direction of acceleration and velocity of a body should be the same? Give an example.

A: Need not. When a body is projected vertically upwards, the direction of velocity is upwards where as the direction of acceleration is downwards.

3. Is it possible for a body to have acceleration but zero velocity? Give an example. [BMP2]

A: Yes.

Ex: In case of a vertically projected body at the Maximum height, its velocity is zero but it has acceleration due to gravity in the downward direction.

4. Which is greater, a velocity of 72 kmph or 25m/s?

A: $72 \text{ kmph} = 72 \times \frac{5}{18} = 20 \text{ m/s}$. So, $25 \text{ m/s} > 72 \text{ kmph}$ $\left[\because 1 \text{ kmph} = \frac{5}{18} \text{ m/s} \right]$

5. Give an example of one dimensional motion, where a particle moving along a straight line comes to rest and moves backward.

A: Oscillation of a simple harmonic oscillator is the example for a particle which moves along a straight line and comes to rest and moves periodically. (to and fro or forward & backward)

6. A vehicle travels half the distance L with speed v_1 and half with speed v_2 . What is the average speed ?

A: Time taken to travel the first half distance, $t_1 = \frac{L}{v_1}$

Time taken to travel the second half distance, $t_2 = \frac{L}{v_2}$

Total time taken, $t = t_1 + t_2 = \frac{L}{v_1} + \frac{L}{v_2} = L \left[\frac{1}{v_1} + \frac{1}{v_2} \right] = L \left[\frac{v_1 + v_2}{v_1 v_2} \right]$

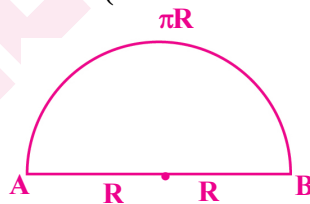
Now average speed (v_{avg}) = $\frac{\text{Total path length}}{\text{Total time taken}} = \frac{L + L}{t_1 + t_2} = \frac{2L}{L \left(\frac{v_1 + v_2}{v_1 v_2} \right)} = \frac{2v_1 v_2}{v_1 + v_2}$

7. A body covers a distance of 5m along a semicircular path from its one end to another end. What is the ratio of its distance covered to its displacement?

A: If R is the radius of semi circle then the distance covered $\pi R = 5\text{m}$ ($\because$ circumference = $2\pi R$)
Displacement between from one end to other end = $2R$

$$\therefore \frac{\text{distance}}{\text{displacement}} = \frac{\pi R}{2R} = \frac{\pi}{2} = \frac{22}{7} \times \frac{1}{2} = \frac{11}{7}$$

$\therefore$ the required ratio is 11:7.



8. Displacement travelled by a body is given by $S = 2t + 5t^2$ m. What is the acceleration of that body? [BMP1]

A: Given displacement $S = 2t + 5t^2$

Velocity $v = \frac{dS}{dt} = 2 + 5(2t) = 2 + 10t$

Acceleration $a = \frac{dv}{dt} = 0 + 10 = 10 \therefore \text{acceleration} = 10 \text{ m/s}^2$

9. An object falling through a fluid is observed to have an acceleration given by $a = g - bv$ where g is the gravitational acceleration and b is a constant. After a long time it is observed to fall with a constant velocity. What would be the value of this constant velocity?

A: At constant velocity the acceleration a becomes 0 $\Rightarrow 0 = g - bv \Rightarrow bv = g \Rightarrow v = g/b$

$\therefore$ The constant velocity is $v = \frac{g}{b}$ ($\because g, b$ are constants)

10. Under what circumstances is the relationship $s = vt$ valid?

A: When the particle moves with **uniform velocity** and along a straight line

3

MOTION IN A PLANE

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

1×2= 2 Marks

1. What are scalars and vectors?

A: 1) **Scalar** is a physical quantity having only magnitude but no direction.

Ex : Length, Mass, Time, Distance etc.

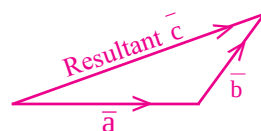
2) **Vector** is a physical quantity having both magnitude and direction.

It obeys law of vector addition .

Ex: Force, Displacement, Velocity, Acceleration etc

2. State Triangle Law of vector addition.

[BMP1]

A: **Triangle law of vectors:** If two vectors are represented in magnitude and direction by the two sides of a triangle taken in an order, then their resultant is represented in magnitude and direction by the third side taken in the reverse order.

3. When two right angled vectors of magnitude 7 units and 24 units combine, what is the magnitude of their resultant ? [IPE' 14] [AP 16,18]

A: Here, $P = 7$ and $Q = 24$ and $\theta = 90^\circ \Rightarrow \cos\theta = \cos 90^\circ = 0$

$$\begin{aligned} \text{Magnitude of Resultant } R &= \sqrt{P^2 + Q^2 + 2PQ\cos 90^\circ} = \sqrt{P^2 + Q^2 + 0} \\ &= \sqrt{7^2 + 24^2} = \sqrt{49 + 576} = \sqrt{625} = 25 \text{ units} \end{aligned}$$

4. If $\vec{P} = 2\vec{i} + 4\vec{j} + 14\vec{k}$ and $\vec{Q} = 4\vec{i} + 4\vec{j} + 10\vec{k}$ find the magnitude of $\vec{P} + \vec{Q}$. [MAR-26]A: $\vec{P} + \vec{Q} = (2\vec{i} + 4\vec{j} + 14\vec{k}) + (4\vec{i} + 4\vec{j} + 10\vec{k}) = 6\vec{i} + 8\vec{j} + 24\vec{k}$

$$\Rightarrow |\vec{P} + \vec{Q}| = \sqrt{6^2 + 8^2 + 24^2} = \sqrt{676} = 26 \text{ units.}$$

 $\therefore$ The magnitude of $\vec{P} + \vec{Q}$ is 26 units.

5. Can two vectors of unequal magnitude add up to give the zero vector ?

Can three unequal vectors add up to give the zero vector?

A: No, the addition of two unequal vectors cannot give a zero vector.
But three unequal vectors lying in a plane can give a zero vector, if triangle law is satisfied.

6. If vertical component of a vector is equal to its horizontal component, what is the angle made by the vector with X-axis ? **[BMP2]** [AP 19,23]

A: Let 'θ' be angle made by the vector $\vec{R}$ with the X-axis.

Vertical component of $\vec{R} = R \sin \theta$; Horizontal component of $\vec{R} = R \cos \theta$

$$\therefore R \cos \theta = R \sin \theta \Rightarrow \sin \theta = \cos \theta \Rightarrow \frac{\sin \theta}{\cos \theta} = 1 \Rightarrow \tan \theta = 1 = \tan 45^\circ \Rightarrow \theta = 45^\circ$$

7. Two forces of magnitude 3 units and 5 units act at 60° with each other. What is the magnitude of their resultant? **[AP 15,16,17]**

A: Here, $P = 3$ and $Q = 5$ and $\theta = 60^\circ \Rightarrow \cos \theta = \cos 60^\circ = 1/2$

$$\text{Magnitude of Resultant } R = \sqrt{P^2 + Q^2 + 2PQ \cos \theta}$$

$$= \sqrt{3^2 + 5^2 + 2 \times 3 \times 5 \times \frac{1}{2}} = \sqrt{9 + 25 + 15} = \sqrt{49} = 7 \text{ units}$$

8. Why does the vertical component of velocity for a projectile change with the time, where the horizontal component of the velocity remains constant in parabolic path?

A: The vertical component of velocity changes due to the constant downward acceleration caused by gravity. Horizontal component remains constant as no forces act horizontally.

4

LAWS OF MOTION

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

V S A Q (2 Marks)

1×2=2 Marks

1. What is inertia ? What gives the measure of inertia ? [MAR-26][BMP1][AP 19]

- A: 1) Inertia is an inherent property of a body, by which it resists any change in its state.
2) Mass is the measure of inertia.

2. When a Bullet is fired from a Gun, the Gun gives a kick in the backward direction. Explain. [AP 15]

- A: The gun kicks back due to the 'law of conservation of momentum'.
When a Bullet is fired from a gun, the momentum of the Gun becomes equal and opposite to that of Bullet.
So, when the Bullet moves forward, the Gun kicks back.

Recoil of the gun

$$v = \frac{mu}{M}$$

3. If a bomb at rest explodes into two pieces, the pieces must travel in opposite directions. Explain. [AP 24]

- A: According to the 'law of conservation of momentum'. $mu = m_1v_1 + m_2v_2$
Initially when the bomb is at rest, we have $u=0 \Rightarrow m_1v_1 + m_2v_2 \Rightarrow m_1v_1 = -m_2v_2$
The negative sign indicates that the two pieces must travel in opposite directions.

4. Define force. What are the basic forces in nature ?

- A: Force is that physical quantity which changes or tries to change the state of a body.
The basic forces in nature are i) Gravitational force ii) Electromagnetic force
iii) Strong nuclear force iv) Weak nuclear force.

5. State the SI units and dimensions of linear momentum.

- A: For linear momentum i) SI unit is kg ms^{-1} (or) Ns
ii) Dimensional Formula = $[MLT^{-1}]$

6. State the SI units and dimensions of impulse.

- A: For impulse i) SI unit is N.s (or) kg.ms^{-1} ,
ii) Dimensional Formula = $[MLT^{-1}]$

7. Can the coefficient of friction be greater than one? Give the reason. [AP 23]

A: Yes. Coefficient of friction may be greater than one in some particular cases.

If the surfaces are **polished heavily** then adhesive forces between the molecules increase and then coefficient of friction will be greater than one.

8. Why does the car with a flattened tyre stop sooner than the one with inflated tyres? [AP 20]

A: A flattened tyre gets more deformation. So **rolling friction becomes more** to that tyre. Hence a car with flattened tyre comes to rest sooner than a car with inflated tyres.

9. A horse has to pull harder during the start of the motion than later. Explain. [BMP2][AP 16,18,22]

A: Before starting the motion, horse has static friction and later it will be converted into kinetic friction. But, Static friction is more than kinetic friction ($f_{ms} > f_k$). Hence, horse has to exert a greater force during the start of the motion than later.

10. What happens to the coefficient of friction if weight of the body is doubled? [AP 16,19]

A: Coefficient of friction remains constant. As it is independent of weight of the body.

11. Write the expressions for maximum possible speed of a car moving on (a) level road (b) banked road.

A: (a) Maximum possible speed of a car on level road is $v_{\max} = \sqrt{\mu_s Rg}$

(b) Maximum possible speed of a car on banked road is $v_{\max} = \sqrt{Rg \tan \theta}$

θ = angle of banking, R = radius of the curve, g = acceleration due to gravity

μ_s = co-efficient of static friction between the tire and road

5

WORK, ENERGY AND POWER

1 VSAQ + 1 LAQ [2M + 8M = 10 M]

VSAQ (2 Marks)

1×2= 2 Marks

1. State the conditions under which a force does no work.

[BMP1][Imp.Q]

A: **Work done** $W = \vec{F} \cdot \vec{S} = |\vec{F}| |\vec{S}| \cos \theta$

Hence, if $\theta = 90^\circ$ then $\cos 90^\circ = 0 \Rightarrow W = 0$

- 1) When force (F) and displacement (S) are mutually perpendicular then work done is zero.
2) Even though when force is applied, if displacement is zero then also work done $W = 0$.

2. Define Work, power and Energy. State their SI units.

[Imp.Q]

A: **Work** : Work is said to be done on a body then force acting on the body moves it, through some distance in the direction of the force. **SI unit of Work** : Joule

Power : The rate of doing work is called power. **SI unit of Power** : Watt.

Energy : The capacity to do work is called Energy. **SI unit of Energy** : Joule

3. State the relation between the kinetic energy and momentum of a body.[BMP2][MAR-26]

A: $K.E = \frac{1}{2} mv^2 = \frac{1}{2} mv^2 \times \frac{m}{m} = \frac{1}{2} \frac{m^2 v^2}{m} = \frac{p^2}{2m}$, where $p = mv$ is momentum of the body.

4. State the sign of work done by a force in the following.

a) Work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket.

b) work done by gravitational force in the above case.

A: a) Work done by the man is **positive**. Because force applied by the man in the displacement of the bucket are in the same direction. ($\therefore \theta = 0^\circ$; $W = FScos\theta = FScos0^\circ = FS$)

b) Work done by the gravity is **negative**. Because gravitational force is acting in the downward direction and bucket is moving in the upward direction.

($\therefore \theta = 180^\circ$; $W = FScos\theta = FScos180^\circ = -FS$)

5. State the sign of work done by a force in the following .

[Imp.Q]

- a) Work done by friction on a body sliding down an inclined plane.
- b) Work done by gravitational force in the above case.

A: a) The work done is negative. Because friction always acts in a direction, opposite to the direction of motion.
b) The work done is positive. Because the angle between the gravitational force and displacement is acute.

6. State the sign of work done by a force in the following

- (a) work done by an applied force on a body moving on a rough horizontal plane with uniform velocity.
- (b) Work done by resistive force of air on a vibrating pendulum in bringing it to rest

A: (a) The work done is positive. Because the applied force and displacement of the body are in the same direction.
(b) The work done is negative. Because resistive force of air on a vibrating pendulum always acts in a direction opposite to the direction of motion of pendulum.

7. State if each of the following statements are true (or) false.

Give reasons to your answer.

- (a) Total energy of a system is always conserved, no matter what internal and external forces on the body are present.
- (b) The work done by earth's gravitational force in keeping the moon in its orbit for its one revolution is zero.

A: (a) True. Total energy of an isolated system will be conserved, if all the forms of energy are taken into account. Energy in one form may be converted into another form, but total energy of the system remains constant.
(b) True. Because the gravitational force is conservative.

6

SYSTEMS OF PARTICLES
& ROTATIONAL MOTION

1VSAQ + 2 SAQ [2M + 4M + 4M = 10 M]

VSAQ (2 Marks)

 $1 \times 2 = 2$ Marks

1. Is it necessary that a mass should be present at the centre of mass of any system?

A: No. It is not necessary for mass to be there at the centre of Mass.

[AP 16]

Ex: Ring has centre of mass at its centre, where there is no mass.

2. Two rigid bodies have same moment of inertia about their axes of symmetry.

Of the two, which body will have greater kinetic energy?

A: $K.E_R = \frac{1}{2} I \omega^2$. For the same moment of Inertia $K.E_R \propto \omega^2$

Hence, the body having greater angular velocity will have greater K.E.

3. Why are spokes provided in a bicycle wheel?

[BMP2]

A: The spokes of cycle wheel increase its moment of inertia.

The greater the moment of inertia, the greater is the opposition to any change in uniform rotational motion. As a result, the cycle runs smoother and steadier.

4. We cannot open or close the door by applying force at hinges. Why? [BMP1][AP 16]

A: Torque = force $\times$ lever arm of the force

[MAR-26]

When the force is applied at hinges, lever arm of the force will be zero ($r=0$).

So there will be no torque and hence we cannot open or close the door.

5. Why do we prefer a spanner of longer arm as compared to the spanner of shorter arm?

A: Torque = force $\times$ lever arm of the force

When we use a spanner of longer arm, lever arm of the force will be large.

So the torque produced will also be more. So the body can be rotated easily.

Hence we prefer a spanner of longer arm to spanner of shorter arm.

6. By spinning eggs on a table top, how will you distinguish a hard boiled egg from a raw egg?

A: A boiled egg is nearly a rigid body and has low moment of inertia. Hence for the same torque boiled egg spins faster.

When a raw egg is spinned, the liquid matter moves away from the rotational axis due to centrifugal force. This would increase the moment of inertia and consequently the angular velocity gets decreased.

7. Why should a helicopter necessarily have two propellers?

A: If there were only one propeller, then according to law of conservation of angular momentum, the helicopter would rotate itself in the opposite direction. So a helicopter necessarily have two propellers.

8. If the polar ice caps of the earth were to melt, what would the effect of the length of the day be?

A: If the polar ice melts, the water formed will spread over the surface of the earth. As a result, the moment of inertia of earth will increase. Since angular momentum $L = I\omega$ of earth remains constant, ω will decrease. The time period increases [$\because I \propto T$].

Hence the length of the day will increase.

9. Why is it easier to balance a bicycle in motion?

A: The rotating wheels of a bicycle possess angular momentum. In the absence of an external torque, neither the magnitude nor the direction of angular momentum change. The direction of angular momentum is along the axis of the wheel. So the bicycle does not get titled.

7

GRAVITATION

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

 $1 \times 2 = 2$ Marks

1. State the unit and dimension of the universal gravitational constant(G). [BMP2]

A: Units of 'G':

C.GS unit: dyne cm²/gm²

S.I unit : Nm²/kg²

Dimensional formula: [M⁻¹L³T⁻²]

2. State the vector form of Newton's law of gravitation.

A: The vector form of Newton's law of gravitation is

$$\vec{F} = G \frac{m_1 m_2}{r^2} (\hat{r}) \quad (\text{or}) \quad \vec{F} = G \frac{m_1 m_2}{r^3} \vec{r} \quad \left(\because \hat{r} = \frac{\vec{r}}{r} \right)$$

Where G is the universal gravitational constant, $\hat{r}$ is the unit vector from m_1 to m_2 and r is the distance between the two bodies.

3. If the gravitational force of the earth on the moon is F, what is the gravitational force of the moon on the earth? Do these forces form an action - reaction pair?

A: The gravitational force of the earth on the moon is F.
The gravitational force of the moon on the earth is -F.
Yes, these forces will form an action- reaction pair.

4. What would be the change in acceleration due to gravity (g) at the surface, if the radius of earth decreases by 2% keeping the mass of earth constant?

A: Given that $\frac{\Delta R}{R} = -2\%$.

$$\text{We know } g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2} \Rightarrow g \propto R^{-2}$$

$$\frac{\Delta g}{g} = \frac{-2\Delta R}{R} = -2 \times (-2\%) = 4\%$$

$\therefore$ As R decreases by 2%, the value of g increases by 4%.

5. As we go from one planet to another how will

(a) the mass and (b) the weight of a body change?

A: (a) The mass of the body remains same

(b) Weight $W = mg \Rightarrow W \propto g$

As 'g' changes from planet to planet weight of the body changes .

6. Keeping the length of a simple pendulum constant, will the time period be the same on all planets? Support your answer with reason.

A: No.

For a Simple Pendulum, Time period $T = 2\pi\sqrt{\frac{l}{g}}$

If l is kept constant then $T \propto \frac{1}{\sqrt{g}}$

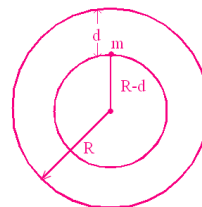
Since, 'g' varies from one Planet to another Planet time period also varies .

7. Give the equation for the value of g at a depth 'd' from the surface of Earth. What is the value of 'g' at the centre of Earth?

A: Formula: $g_d = g\left(1 - \frac{d}{R}\right)$

Where d = depth from the surface of earth, R = radius of the earth.

At the centre of the earth $d = R$. Hence, $g_d = 0$.



8. What are the factors that make 'g' the least at the equator and maximum at the poles?

[MAR-26]

A: The factors that make 'g', the least at the equator and maximum at the poles are

- Non sphericity (In reality shape of the earth is not in perfect spherical shape)
- Rotation of the earth

The **large radius and centrifugal force** at the **equator** results **lowest 'g'** value at the equator.

The **smaller radius** at the pole and the **absence of significant centrifugal force** contribute to the highest 'g' value at the poles.

9. "Hydrogen is in abundance around the sun but not around the earth." Explain.

[BMP1]

A: The r.m.s velocity of hydrogen molecules is around 2km/s.

The escape velocity on the surface of earth is 11.2km/s.

But the escape velocity on the surface of sun is 620km/s.

The escape velocity of sun is greater than escape velocity of earth and r.m.s velocity of hydrogen

Also, the gravitational attraction of the sun is more than the earth.

Hence hydrogen is in abundance around the Sun and less around the earth.

8

MECHANICAL PROPERTIES OF SOLIDS

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

1 × 2 = 2 Marks

1. What is elasticity?

A: **Elasticity** is the property of a body, by virtue of which, it regains its original Size and Shape when the deforming force is removed.
Elasticity is a Molecular property of Matter.

2. What is elastic deformation?

A: **Elastic deformation** refers to the temporary change in shape of a material when a force is applied, with the material returning to its original shape upon the removal of the force.

3. What are elastomers? Give an example.

A: The substances that can be stretched to large and return to their original shape. **Ex:** Rubber.

4. What is plasticity?

A: **Plasticity** is the property of a body by virtue of which, it does not regain its original size and shape on the removal of deforming force.

5. State Hooke's law of elasticity.

[MAR-26][BMP2]

A: **Hooke's Law** : Within the elastic limit, the stress is directly proportional to strain.
Thus, stress $\propto$ strain $\Rightarrow$ stress = E (strain). Here E is called as modulus of elasticity.

6. Define modulus of elasticity.

[BMP1]

A: **Modulus of Elasticity (E)** of the material of a body is the ratio of Stress and Strain.

$$\text{Formula: } E = \frac{\text{Stress}}{\text{Strain}}$$

7. State the units and dimensions of stress.

A: **Stress:**

C.G.S Unit: dyne cm^{-2} **S.I Unit :** N m^{-2} (or) Pascal

Dimensional Formula : $[\text{ML}^{-1}\text{T}^{-2}]$

8. State the units and dimensions of modulus of elasticity.

A: **Modulus of elasticity :**

C.G.S Unit : dyne cm^{-2} **S.I Unit :** N m^{-2} (or) Pascal

Dimensional formula : $[\text{ML}^{-1}\text{T}^{-2}]$

9. What is lateral strain?

A: Lateral strain is the change in dimension perpendicular to the direction of an applied force.

10. What is Poisson's ratio? What is the value of Poisson's ratio for steel?

A: **Poisson's ratio(σ)** is the ratio of lateral contractional strain to the longitudinal elongational strain. For Steel Poisson's ratio is 0.28 to 0.30.

9

MECHANICAL PROPERTIES OF FLUIDS

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

 $1 \times 2 = 2$ Marks

1. Define average pressure. Is it a scalar or a vector quantity? [AP 17,20,22]

A: Average pressure is defined as the normal force acting per unit area. $P_{\text{avg}} = \frac{F}{A}$

It is a scalar quantity.

2. What is magnus effect? [AP 15]

A: 1) **Magnus effect:** It is the 'dynamic lift' arised due to spinning of a moving ball .
 2) When a ball is 'moving forward with spinning' then the velocity of air above the ball is larger and below the ball is smaller. This difference in the velocities of air results in the 'pressure difference' between the upper and lower surfaces. This causes a spinning in its track.

3. Why are liquid drops and bubbles spherical? [AP 16,17,18,22]

A: 1) Due to **surface tension** rain drops and water bubbles are spherical in nature.
 2) For a given volume, **Sphere has minimum surface area**. So liquid drops attain spherical shape.

- 4 Give the expression for the excess pressure in a liquid drop. [BMP2] [AP 23]

A: 1) Liquid drop in air contains only one interface.

2) Hence, excess pressure in a liquid drop = $P_{\text{inside}} - P_{\text{outside}} \Rightarrow P_{\text{excess}} = \frac{2T}{r} = P_{\text{inside}} - P_{\text{outside}}$

Where, r = radius of the liquid drop

T = surface tension of the liquid-air interface.

5. Give the expression for the excess pressure in an air bubble inside the liquid.

A: 1) An air bubble inside the liquid contain only one free surface.

2) The excess pressure is $P = \frac{2T}{r}$, where r = radius of the air bubble, T = surface tension

6. Give the expression for the excess pressure in the soap bubble in air.

A: 1) Soap bubble in air contains two interfaces.

[MAR-26][AP 19]

$$2) \text{ Hence, excess pressure in soap bubble} = P_{\text{inside}} - P_{\text{outside}} \Rightarrow P_{\text{excess}} = \frac{4T}{r}$$

Where, r = radius of bubble;

T = surface tension of liquid-air interface.

7. What is the angle of contact?

[BMP1][AP 16,23]

A: **Angle of contact** is the angle between solid surface and the tangent drawn to the liquid surface.

It is observed at the point of contact, inside the liquid when a solid body is dipped in a Liquid.

For Pure Water and glass, angle of contact is 0° .

For Mercury and glass, angle of contact is 140° .

8. Mention any two examples that obey Bernoulli's theorem and justify them. [AP 18]

A: **Examples:** Aeroplane wings, Blowing of papers on the table, house roofs, during heavy winds.

1) When a fan is switched on, papers on the table will be blown off. The velocity of air on the paper increases due to fan and hence 'pressure difference' arises. This causes dynamic lift.

2) During heavy winds, house roofs are blown off, when the velocity of wind is greater on the roof top than inside the house. This pressure difference causes the dynamic lift and hence the roof is blown off.

9. When water flows through a pipe, which of the layers moves fastest and slowest ?

A: 1) The middle central layer moves faster.

2) The outer water layer which is in contact with the walls of the pipe moves slower.

10. Explain why terminal velocity is higher for a body with a larger surface area.

A: Terminal velocity $v_t \propto r^2 \Rightarrow v_t \propto 4\pi r^2 \Rightarrow V_t \propto A$, [Since, $A = 4\pi r^2$ = surface area of sphere]
Thus terminal velocity is directly proportional to surface area.

Hence, terminal velocity is higher for a body with a larger surface area.

11. What is the net force acting on a ball that is moving in air?

(a) Without spin (b) With spin.

A: (a) When the ball is moving without spin, **Net force** is **zero**

(b) When the ball is spinning in air, the Net force is the vector sum of gravity, drag and lift.

$\therefore$ Net force acting on a ball that is moving in air with spin is upward.

10

THERMAL PROPERTIES OF MATTER

1 VSAQ +2 SAQ [2M + 4M + 4M= 10M]

VSAQ (2 Marks)

1 × 2 = 2 Marks

1. Distinguish between heat and temperature. [AP 25]

A:	<table><tr><th>HEAT</th><th>TEMPERATURE</th></tr><tr><td>1) Heat is a form of energy transferred between two systems due to temperature difference</td><td>1) Temperature is a measure of thermal energy.</td></tr><tr><td>2) C.G.S unit: Calorie S.I unit: joule</td><td>2) C.G.S unit: °C S.I unit: kelvin</td></tr><tr><td>3) A calorimeter is used to measure the amount of heat in a substance</td><td>3) A thermometer is used to measure the temperature of a substance.</td></tr></table>	HEAT	TEMPERATURE	1) Heat is a form of energy transferred between two systems due to temperature difference	1) Temperature is a measure of thermal energy.	2) C.G.S unit: Calorie S.I unit: joule	2) C.G.S unit: °C S.I unit: kelvin	3) A calorimeter is used to measure the amount of heat in a substance	3) A thermometer is used to measure the temperature of a substance.
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2. What are the lower and upper fixing points in Celsius and Fahrenheit scales? [AP 19]

A: On Celsius scale, the lower fixed point is 0°C and the upper fixed point is 100°C. On Fahrenheit scale, the lower fixed point is 32°F and the upper fixed point is 212°F.

3. Do the values of coefficients of expansion differ when the temperatures are measured on Centigrade scale or on Fahrenheit scale?

A: Yes.
Since one degree interval on Fahrenheit scale is less than one degree interval on Celsius scale.

4. Can a substance contract on heating? Give an example. [AP 18,22]

A: Yes. Some substances contract on heating.
Ex: Cast iron, Natural Rubber, type metal and pure water between 0°C to 4°C.

5. Why gaps are left between rails on a railway track? [AP 15,16,17,19,19,22]

A: A small gap is left between the ends of successive rails on a railway track. This is to allow **linear expansion** of rails in summer.

6. What is latent heat of fusion? [AP 23,24]

A: **Latent heat of fusion** : It is the amount of heat required to change the state of unit mass substance from solid to liquid at constant temperature and pressure.
For water, the latent heat of fusion is 80 calgm⁻¹

7. What is latent heat of vapourisation?

A: **Latent heat of vapourisation of water** is the amount of heat required to change 'unit mass of a liquid' into vapour, at constant temperature .

For water the latent heat of vapourisation 540 cal gm^{-1}

8. Why utensils are coated black? Why the bottom of the utensils are made of copper?

[AP 18]

A: 1) Black bodies are good absorbers of heat. So, black coated utensils absorb heat quickly.
2) Copper is a good conductor of heat. So, copper bottom utensils absorb heat slowly. Hence it promotes the distribution of heat over the bottom of a vessel for uniform cooking.

9. State Weins displacement law?

[AP 17,19,23]

A: **Weins displacement law:** The wavelength (λ_m) for which energy is maximum is inversely proportional to absolute temperature of the body.

$$\text{i.e } \lambda_m \propto \frac{1}{T} \quad (\text{or}) \quad \lambda_m = \frac{\text{Constant}}{T} \quad (\text{or}) \quad \lambda_m T = \text{Constant}$$

Wein's constant is $2.9 \times 10^{-3} \text{ mK}$

10. Ventilators are provided in rooms just below the roof. Why?

[AP 20]

A: Hot air has less density. So it moves upwards due to convection.

To escape this hot air out of the room, ventilators are provided just below the roof.

11. Does the body radiate heat at 0K? Does it radiate heat at 0°C?

A: 1) No, the body does not radiate heat at 0K.

2) Yes, the body radiates heat at 0°C.

12. State the different modes of transmission of heat. Which of these modes require medium?

A: **There are three distinct modes of heat transfer :**

1) Conduction 2) Convection and 3) Radiation

Conduction and convection of heat are required material medium.

13. Define coefficient of thermal conductivity and temperature gradient.

A: The quantity of heat flowing normally per second through unit area of the substance per unit temperature gradient is called "coefficient of thermal conductivity".

$$K = \frac{Qd}{A(\theta_2 - \theta_1)t} = \frac{(Q/t)}{A(\Delta\theta/d)}$$

The change in temperature per unit distance moved in the direction of flow of heat is called temperature gradient.

$$\text{Temperature gradient} = \frac{(\theta_2 - \theta_1)}{d} = \frac{\Delta\theta}{d}$$

14. Define emissivity.**[BMP1]**

A: **Emissivity** is the ratio of the emissive power of a body to that of black body, at the same temperature.

15. Define absorptive power of a body. What is the absorptive power of a perfect blackbody.

A: **Absorptive power** is the ratio between energy flux absorbed in certain time to total energy flux incident on the body in the same time.

The absorptive power of a black body is 1.

16. State Newton's law of cooling.**[AP 15,16,18,20]**

A: **Newton's law of cooling** states that the 'rate of loss of heat of a hot body' is directly proportional to the 'difference in temperature' between the 'body and its surroundings'.

Formula: $-\frac{dQ}{dt} \propto (T_2 - T_1)$

17. State the conditions under which Newton's law of cooling is applicable.

A: **Newton's law of cooling is applicable** when

- 1) Heat lost by the body is mainly due to **convection**
 - 2) Loss of heat is negligible by **conduction**
 - 3) The hot body is cooled by forced **convection**
 - 4) The temperature is uniform throughout the body.
-

18. The roof of buildings are often painted white during summer. Why?**[MAR-26][BMP2] [AP 16,24]**

- A:**
- 1) **White paint** is a **good reflector of heat**. Good reflector is a bad absorber of heat.
 - 2) So roof of buildings that are painted white to **'keep cool' during summer**.

11

THERMODYNAMICS

1 VSAQ + 1 LAQ [2M + 8M = 10 M]

VSAQ (2 Marks)**1 × 2 = 2 Marks**

1. **Define Thermal equilibrium. How does it lead to Zeroth law of Thermodynamics?**

A: Thermal equilibrium:

[BMP1]

Two systems are said to be in thermal equilibrium, if the temperatures of two systems are equal and there is no net flow of heat between them when they are brought into thermal contact.

Zeroth law of Thermodynamics:

If two systems are in thermal equilibrium with a third system separately then they must be in thermal equilibrium with each other.

2. **Define Calorie. What is the relation between calorie and mechanical equivalent of heat?**

A: Calorie: The amount of heat required to raise the temperature of one gram of water through 1°C (14.5° to 15.5°C) at a pressure of 1 atm, is called calorie.

Mechanical equivalent of heat (J) is defined as the amount of work needed to produce 1 calorie heat.

∴ 1 calorie = 4.186 joule

3. **What thermodynamic variables can be defined by (a) Zeroth law (b) First law?** **[MAR-26]**

A: a) Thermodynamic variable defined by Zeroth law of thermodynamics is **temperature**.

b) Thermodynamic variable defined by First law of thermodynamics is **internal energy**.

4. **Define specific heat capacity of the substance. On what factors does it depend?**

A: Specific heat capacity is the amount of heat required by unit mass of substance to raise its

temperature by one degree. **Formula:** $S = \frac{1}{m} \left(\frac{dQ}{dT} \right)$

Specific heat capacity depends on the nature of the substance and its temperature.

5. **Define molar specific heat capacity.**

A: Molar specific heat capacity is the amount of heat required by one mole of substance to raise its temperature by one degree.

Formula: $C = \frac{1}{n} \left(\frac{dQ}{dT} \right)$

6. For a solid, what is the total energy of an oscillator?

A: Average energy of an oscillator in one dimension = $2 \times \frac{1}{2} K_B T = K_B T$

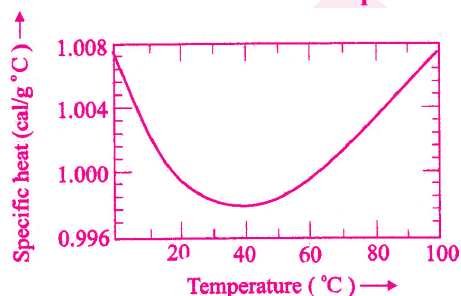
Average energy of an oscillator in three dimension = $3K_B T$

For one mole of solid, the total energy is $U = 3K_B T \times N_A = 3RT$ ($\because R = N_A K_B$)

Where N_A = Avogadro number.

7. Indicate the graph showing the variation of specific heat of water with temperature. What does it signify?

A: It specifies the unit temperature interval as 14.5°C to 15.5°C for a precise definition of calorie.



8. Define state variables and equation of state.

A: **State variables** are the specific values of some macroscopic variables like pressure, volume, temperature and mass which completely describe an equilibrium state of a thermodynamic system.

Equation of state is the relation between the state variables.

Ex: For an ideal gas, the equation of state is the ideal gas relation $PV = nRT$

9. In summer, when the valve of a bicycle tube is opened, the escaping air appears cold. why? [BMP2]

A: The pressure of air inside the tube is sufficiently greater than atmospheric pressure. When the valve of a bicycle tube is opened, the air expands under adiabatic process. It does some work against surroundings and so its internal energy decreases. This causes a fall in temperature. Hence escaping air from a bicycle tube appears cold.

10. Why does the brake drum of an automobile get heated up while moving down at constant speed?

A: Since the speed is constant there is no change of kinetic energy.

The loss in gravitational potential energy is partially converted into heat energy of the brake drum of an automobile while moving down at constant speed.

11. Can a room be cooled by leaving the door of an electric refrigerator open?

A: No. The room cannot be cooled by opening the door of an electric refrigerator.

A refrigerator extracts heat from the freezing chamber(cold reservoir), some work is done on it by electric motor and rejects heat into the surrounding(hot reservoir) air.

If the door of a running refrigerator is left open, more heat is rejected to the surroundings.

Hence the room will get slightly heated.

12. A sound wave is sent into a gas pipe. Does its internal energy change?

A: Yes. The propagation of sound wave through a pipe is a quick process. It is an adiabatic change where temperature increases. $\therefore$ internal energy also increases.

13. How much will be the internal energy change in

i) isothermal process ii) adiabatic process

A: i) There is no change in the internal energy of an ideal gas in an isothermal process.

i.e $dU=0$

ii) For adiabatic process $dQ=0$

Hence $dU = -dW$

Work done by the gas results in decrease in its internal energy.

If work is done on the gas then its internal energy increases.

14. The coolant in a chemical or a nuclear plant should have high specific heat. Why?

A: By allowing water to flow in pipes around the heated parts of a machine heat energy from such parts is removed. Water in pipes extracts more heat without much rise in its temperature because of its large specific heat.

15. Explain the following processes

i) Isochoric process

ii) Isobaric process

A: **i) Isochoric process:** is a process that takes place at constant volume of the system.

Ex: Heat is added to the gas enclosed in a cylinder having rigid walls and a fixed piston.

ii) Isobaric process is a process that takes place at constant pressure of the system.

Ex: Heating of water at atmospheric pressure.

12

KINETIC THEORY

1 OMQ + 1 VSAQ + 1 SAQ [1 M + 2M + 4M = 7 M]

VSAQ (2 Marks)

1 × 2 = 2 Marks

1. Define mean free path.

[MAR-26] [AP 17,18,19,20,22,23,25]

A: Mean free path is the average distance covered by a molecule between two successive collisions.

$$\bar{l} = \frac{1}{\sqrt{2}n\pi d^2}$$

Where n is the number density and d is the diameter of the molecule.

2. How does kinetic theory justify Avogadro's hypothesis and show that Avogadro Number in different gases is same?

A: Consider same values of P, V and T for different gases. R is a universal gas constant which is also same for different gases. Then it follows from $n = \frac{PV}{RT}$ that 'n' is same for different gases. This confirms Avogadro's hypothesis. The number of molecules in 22.4 litres of any gas is 6.02×10^{23} . This is known as Avogadro number.

3. When does a real gas behave like an ideal gas?

[BMP2] [AP 22,25]

A: At low pressure and high temperature a real gas behaves like an ideal gas.

4. State Boyle's law and Charles law.

[AP 20,23,24]

A: 1) **Boyle's law:** At constant temperature(T), the pressure (P) of a given mass of gas is inversely proportional to its volume (V).

Thus $P \propto \frac{1}{V}$, (T is constant) (or) $PV = \text{Constant}$,

2) **Charles law:** At constant pressure(P), the volume(V) of a given mass of a gas is directly proportional to its temperature (T) on Kelvin scale.

Thus $V \propto T$, (P is constant) (or) $\frac{V}{T} = \text{Constant}$

5 State Dalton's law of partial pressures.

[AP 16]

A: **Dalton's law of partial pressure** states that total pressure of a mixture of ideal gases is the sum of partial pressures.

$P = P_1 + P_2 + P_3 + \dots$ - where $P_1, P_2, P_3, \dots$ are partial pressures.

6. Pressure of an ideal gas in container is independent of shape of the container-explain

A: The pressure of an ideal gas in container $= \frac{1}{3} n m \bar{v}^2$ [AP 15,18]

This pressure is independent of area A. By Pascal's law, pressure in one portion of the gas in equilibrium is the same as any where else. Hence pressure of an ideal gas in container is independent of shape of the container.

7. Explain the concept of degrees of freedom for molecules of a gas.

A: The total number of possible independent ways in which the particles of a system can take up energy is called the degree of freedom of that system.

A molecule free to move in space has three translational degrees of freedom.

Each atom of a monoatomic gas has only three translational degrees of freedom.

A diatomic molecule has 5 degrees of freedom(3 translational and 2 rotational).

8. What is the expression between pressure and kinetic energy of a gas molecule?

A: The pressure of an ideal gas $P = \frac{1}{3} n m \bar{v}^2$ [BMP1][AP 15,16,17]

$$= \frac{1}{3} \frac{N m}{V} \bar{v}^2 = \frac{2}{3} \times \left(\frac{1}{2} m \bar{v}^2 \right) \frac{N}{V} = \frac{2}{3} \times \frac{E}{V}$$

where $E = N \times \frac{1}{2} m \bar{v}^2 =$ internal energy of an ideal gas

Thus, the pressure exerted by a gas is numerically equal to $2/3^{\text{rd}}$ of the kinetic energy of the molecules present per unit volume of the gas.

9. The absolute temperature of a gas is increased 3 times. What will be the increase in rms velocity of the gas molecule? [AP 19,24]

A: The rms velocity of the gas molecule $= C = \sqrt{\frac{3RT}{M}} \Rightarrow C \propto \sqrt{T} \Rightarrow \frac{C_1}{C_2} = \sqrt{\frac{T_1}{T_2}}$

Given $T_2 = 3 T_1$

$$\therefore \frac{C_1}{C_2} = \sqrt{\frac{T_1}{3T_1}} \Rightarrow C_2 = \sqrt{3} C_1$$

The r.m.s velocity of the gas molecule becomes $\sqrt{3}$ times of initial rms velocity.

Increase in r.m.s velocity of the gas molecule $= C_2 - C_1 = \sqrt{3} C_1 - C_1 = 1.732 C_1 - C_1 = 0.732 C_1$

Percentage increase in rms velocity $= \frac{C_2 - C_1}{C_1} \times 100 = 73.2\%$

13

OSCILLATIONS

1 VSAQ + 1 LAQ [2M + 8M = 10M]

VSAQ (2 Marks)

 $1 \times 2 = 2$ Marks

1. Give two examples of periodic motion which are not oscillatory.

A: The revolution of Planets around the Sun is Periodic, but it is not Oscillatory. Similarly, the revolution of Electrons around the Nucleus is Periodic, but it is not Oscillatory.

2. The displacement in S.H.M is given by $y = A \sin(20t + 4)$.

What is the displacement when it is increased by $2\pi/\omega$?

A: Given $y = A \sin(20t + 4)$

We know time period of S.H.M is $T = \frac{2\pi}{\omega}$,

So when time is increased by one time period, the body will have the same displacement.

3. A girl is swinging seated in a swing. What is the effect on the frequency of oscillation if she stands?

A: If girl stands, the effective length of the swing **decreases** due to rise in the position of centre of mass.

Since $T \propto \sqrt{l}$, Time period **decreases**, so frequency increases.

Frequency

$$n = \frac{1}{2\pi} \sqrt{\frac{l}{g}}$$

4. The bob of a simple pendulum is a hollow sphere filled with water. How will the period of oscillation change, if the water begins to drain out of the hollow sphere?

A: As water begins to drain out from the hollow sphere, the centre of mass of (sphere + water) system goes down. So the effective length of pendulum increases. As $T \propto \sqrt{l}$, the time period (T) also increases.

When water is completely drained out the centre of mass comes to its original position (i.e., centre of the sphere). So the pendulum will have its original time period.

5. The bob of a simple pendulum is made of wood. What will be the effect on the time period if the wooden bob is replaced by an identical bob of aluminum?

A: The time period of a simple pendulum does not depend upon the size, shape or material of the bob as long as its length is kept constant. So if the wooden bob is replaced by identical aluminium bob, there will be no change in its time period

6. Will a pendulum clock gain or lose time when taken to the top of a mountain?

A: The time period of a pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$

When a pendulum clock is taken to the top of the mountain, its time period increases, because as we go upwards from the surface of earth the value of g decreases.

As time period increases, it will take more time to complete one oscillation, so the pendulum clock loses time. Hence, it will go slow.

7. A pendulum clock gives correct time at the equator. Will it gain or lose time if it is taken to the poles? If so, why?

A: At poles the value of ' g ' is more.

The relation between time period (T) and g is $T = 2\pi\sqrt{\frac{l}{g}}$

So as ' g ' increases, T decreases.

As time period (T) decreases it will make more oscillations. So the clock gains time.

8. What fraction of the total energy is K.E when the displacement is one half of amplitude of a particle executing S.H.M? [BMP2]

A: Total energy of a particle executing S.H.M is $T.E = \frac{1}{2}m\omega^2 A^2$

where m =mass of the particle; ω = angular velocity; A = amplitude

K.E of the particle at a displacement y is $K.E = \frac{1}{2}m\omega^2 (A^2 - y^2)$

When $y = \frac{A}{2}$, $K.E = \frac{1}{2}m\omega^2 (A^2 - \frac{A^2}{4}) = \frac{1}{2}m\omega^2 \left(\frac{3A^2}{4} \right)$

Now, $\frac{K.E}{T.E} = \frac{\frac{1}{2}m\omega^2 \left(\frac{3A^2}{4} \right)}{\frac{1}{2}m\omega^2 A^2} = \frac{3}{4}$

So, K.E is $\frac{3}{4}$ of T.E when displacement is half of amplitude.

9. What happens to the energy of a simple harmonic oscillator if its amplitude is doubled?

A: Total energy of a simple harmonic oscillator is $T.E = \frac{1}{2}m\omega^2 A^2$ **[MAR-26]**

where m = mass of the particle; ω = angular velocity; A = amplitude

When amplitude is doubled, the new T.E will be

$$T.E = \frac{1}{2}m\omega^2 (2A)^2 \Rightarrow 4 \times \frac{1}{2}m\omega^2 A^2 = 4 \times \text{initial T.E}$$

So total energy will be increased to 4 times.

10. Can a simple pendulum be used in an artificial satellite? Why? **[BMP1]**

A: No. Inside an artificial satellite, the effective value of g is zero.

The time period of the simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$

As $g = 0$, $T = \infty$. Thus, inside a satellite, the pendulum does not oscillate. So a simple pendulum cannot be used in an artificial satellite.

14

WAVES

1 OMQ+1 VSAQ + 1 SAQ [1M+2M+4M=7M]

VSAQ (2 Marks)

 $1 \times 2 = 2$ Marks

1. Distinguish between longitudinal and transverse waves.

A:	Longitudinal Waves	Transverse Waves
	1) Waves in which the particles of the medium vibrate along the direction of wave propagation are called longitudinal waves. Ex: Sound waves in air.	1) Waves in which the particles of the medium vibrate in perpendicular to the direction of wave propagation are called transverse waves. Ex: Waves on a stretched string.
	2) In longitudinal waves, compressions and rarefactions are formed alternately.	2) In transverse waves, crests and troughs are formed alternately.
	3) Longitudinal waves do not exhibit the property of polarization.	3) Transverse waves exhibit the property of polarization.

2. What is a stationary or standing wave?

A: Stationary Wave:

When two progressive waves travelling in opposite direction along a line are super imposed then the waves formed are called stationary waves.

3. Using dimensional analysis obtain an expression for the speed of transverse waves in a stretched string.

A: Speed of a Transverse Wave in a Stretched String: The speed of a transverse wave (V) in a stretched string depends on tension (T) and the linear density (μ) of the string. Hence, wave speed $V \propto T^a \mu^b \Rightarrow V = K T^a \mu^b \dots (1)$

Dimensions of $V = M^0 L^1 T^{-1}$ Dimensions of Tension $T = M^1 L^1 T^{-2}$ Dimensions of Linear mass $\mu = M^1 L^{-1}$ Dimensions of constant $K = M^0 L^0 T^0$

$$\therefore (1) \Rightarrow M^0 L^1 T^{-1} = [M^1 L^1 T^{-2}]^a [M^1 L^{-1}]^b \Rightarrow M^0 L^1 T^{-1} = M^{a+b} L^{a-b} T^{-2a}$$

Equating the powers of M, L, T, we have $-2a = -1 \Rightarrow a = 1/2$

$$a+b=0 \Rightarrow b = -a = -1/2$$

Experimentally the proportionality constant $K = 1$. $\therefore V = 1 \cdot T^{1/2} \mu^{-1/2} = \frac{T^{1/2}}{\mu^{1/2}} = \sqrt{\frac{T}{\mu}}$

Alternative Easy method: As linear density $\mu = \frac{\text{mass}}{\text{length}}$, $\mu = M L^{-1}$

$$\frac{T}{\mu} = \frac{MLT^{-2}}{ML^{-1}} = L^2T^{-2} = (LT^{-1})^2 = \text{speed}^2$$

Hence, the speed of transverse wave on a stretched string is $V = K\sqrt{\frac{T}{\mu}}$

The proportionality constant K is proved to be 1.

∴ The equation for speed of **transverse wave** on a stretched string is $V = \sqrt{\frac{T}{\mu}}$

4. Using dimensional analysis obtain an expression for the speed of sound waves in a medium.

A: Speed of a Longitudinal Wave (Sound Wave):

In longitudinal waves, its speed (v) depends on elastic property i.e, bulk modulus(B) and density (ρ) of the medium.

Speed $v = L T^{-1}$.

Bulk modulus $B = \frac{\Delta P}{\Delta V / V} = ML^{-1}T^{-2}$, Density $\rho = ML^{-3}$

Now, $\frac{B}{\rho} = \frac{ML^{-1}T^{-2}}{ML^{-3}} = L^2T^{-2} = (LT^{-1})^2 = v^2$

Hence, the speed of longitudinal wave is $v = K\sqrt{\frac{B}{\rho}}$

Experimentally the proportionality constant K= 1.

∴ The speed of longitudinal wave (sound) in a medium is $v = \sqrt{\frac{B}{\rho}}$

5. What is the principle of superposition of waves?

A: Principle of Superposition :

When a medium is subjected to two or more waves simultaneously, the resultant displacement at any point is equal to the algebraic sum of displacements of all the waves.

$$y = y_1 + y_2 + y_3 + \dots$$

This principle explains the phenomena of stationary waves, beats etc.

6. What do you understand by the terms 'node' and 'antinode'?

A: When stationary waves are formed in a medium, the positions of **zero** (or minimum) **amplitude** are called nodes.

At nodes, amplitude of the stationary wave $a_N = a_1 - a_2$

The positions of **maximum amplitude** are called antinodes.

At antinodes, amplitude of the stationary wave $a_{AN} = a_1 + a_2$

7. What do you understand by natural frequency or normal mode of vibration?

A: When a body is set into vibration and then left to itself, the vibrations made by it are called natural or free vibrations. Its frequency is called natural frequency or normal mode of vibration.

(OR)

When stationary waves are formed in a stretched string or closed tube or open tube, the medium in it can vibrate with certain wavelengths or frequencies only. One of these possible vibrations is called natural frequency or normal mode of vibration.

8. What are harmonics ?**[BMP2]**

A: The integral multiples of fundamental frequencies are called harmonics.

(OR)

When stationary waves are formed in a stretched string or a closed tube or an open tube, the medium in it can vibrate with certain wavelengths or frequencies which are called harmonics.

9. What are 'beats' ?**[MAR-26][BMP1]**

A: Beats: When two sounds of slightly different frequencies are travelling in same direction along the same line of action, the intensity of their resultant sound 'waxes and wanes' periodically. This phenomenon is called beats.

Beats are formed due to interference of sound waves in time.

10. Write down an expression for beat frequency and explain the terms therein.

A: Beat frequency $\nu_{\text{beat}} = \nu_1 \sim \nu_2$

where ν_1, ν_2 are the frequencies of first and second sounds producing beats.