Class 9

PHYSICS

Chapter: Laws of Motion

Multiple Choice Questions:-

1. Which of the following is a contact force?

(a) Gravitational force
(b) Electrostatic force
(c) Magnetic force
(d) Frictional force

Ans. (d) The forces which are applied on objects by making a physical contact with them are called contact forces e.g., frictional force.

2. Identify the non-contact force among the following options.

(a) Force of friction
(b) Force due to gravity
(c) Force of reaction
(d) Tension in a string

Ans. (b) The forces experienced by objects even without being physically in touch are called non-contact forces e.g., force due to gravity.

3. The property of inertia is more in

(a) A horse cart
(b) A car
(c) A truck
(d) A toy car

Ans. (c) As we know, more the mass, more is the inertia of the body. As truck is the heaviest, hence inertia of truck will be

maximum.

4. A tennis ball and a cricket ball, both are stationary. To start motion in both the balls

(a) a less force is required for the cricket ball than for the tennis ball

(b) less force is required for the tennis ball than for the cricket ball

(c) same force is required for both the balls

(d) nothing can be said.

Ans. (b) Less mass means less inertia. Since the mass of the tennis ball is less than the cricket ball, less force is required for the tennis ball to start motion.

5. A force is required to

(a) change the state of motion or state of rest of an object

(b) keep the velocity of object constant

(c) keep the object stationary

(d) keep the object in motion

Ans. (a) According to Newton's first law, an object remains in its state of rest or uniform motion unless an external force acts on it.

6. Identify the unit of force:

(a) kg m s^{-1}

(b) kg m s^{2}

(c) kg m s

(d) kg m s^{-2}

Ans. (d) kg m s^{-2} (Newton).

7. The linear momentum of an object of mass m moving with velocity v is

(a) m/v

(b) v/m

(c) $(mv)^{-1}$

(d) mv

Ans. (d) Linear momentum p is defined as the product of mass and velocity, p = mv.

8. Among the following, choose the object possessing the highest momentum:

(a) Mass of 8 kg moving with velocity 6 m s^{-1}

(b) Mass of 4 kg moving with velocity 11 m s^{-1}

(c) Mass of 10 kg moving with velocity 4 m s^{-1}

(d) Mass of 45 kg moving with velocity 1 m s^{-1}

Ans. (a) Mass of 8 kg × 6 m/s = 48 kg m s^{-1}, which is highest among all options.

9. The unit of linear momentum is

(a) N s

(b) kg m s^{-2}

(c) N s^{-1}

(d) kg^2 m s^{-1}

Ans. (a) N s (or kg m s^{-1}).

10. A player catches a cricket ball of mass 0.150 kg moving at a rate of 20 m s^{-1} and completes this process in 0.1 s. The force exerted by the ball on the hand of the player is

(a) 0.3 N

(b) 300 N

(c) 30 N

(d) 150 N

Ans. (c) $F = m \times (\Delta v / \Delta t) = 0.15 \times (0 - 20) / 0.1 = -30$ N. Magnitude of force is 30 N.

11. The correct form of Newton's second law is

(a) $F = \Delta p / \Delta t$

(b) $F = m \Delta v / \Delta t$

(c) $F = v \Delta m / \Delta t$

(d) $F = mv$

Ans. (a) Rate of change of momentum, $F = \Delta p / \Delta t$.

12. The acceleration produced in an object by a force of given magnitude depends on

(a) size of the object
(b) mass of the object
(c) shape of the object
(d) size and shape of the object

Ans. (b) Mass of the object ($a = F/m$).

13. Newton's third law:

(a) defines the force quantitatively
(b) defines the force qualitatively
(c) gives the direction of force
(d) explains the way a force acts on an object

Ans. (d) Explains the way a force acts on an object (action and reaction).

14. Action and reaction act on the—

(a) same object in opposite directions
(b) same object in same direction
(c) different objects in opposite directions
(d) different objects, but in the same direction

Ans. (c) Action and reaction act on different objects in opposite directions.

15. An object is projected vertically upward with an initial velocity u. If acceleration due to gravity is g, the time for which it remains in air, is

(a) u/g
(b) ug
(c) 2u/g
(d) u/2g

Ans. (c) Time of flight = 2u/g.

16. An object falling freely from rest reaches ground in 2 s. If acceleration due to gravity is 9.8 m s^{-2}, the velocity of the object

on reaching the ground will be

(a) 9.8 m s^{-1}

(b) 4.9 m s^{-1}

(c) 19.6 m s^{-1}

(d) 0

Ans. (c) $v = u + gt = 0 + 9.8 \times 2 = 19.6$ m s^{-1}.

17. An object is moving along a straight path in an accelerated motion. Choose the correct statement from the following:

(a) Its speed keeps changing

(b) Its velocity always changes

(c) It always goes away from the earth

(d) A force is always acting on it

Ans. (b) Its velocity always changes.

18. According to the third law of motion, action and reaction

(a) act on either body at normal to each other

(b) have same magnitude and directions

(c) always act on different bodies in opposite directions

(d) always act on the same body

Ans. (c) Always act on different bodies in opposite directions.

19. A goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal. This enables the goalkeeper to

(a) increase the rate of change of momentum

(b) decrease the rate of change of momentum

(c) reduce the force exerted by the ball on hands

(d) exert larger force on the ball

Ans. (c) Reduce the force exerted by the ball on hands by increasing the time taken.

20. The inertia of an object tends to cause the object

(a) to decrease its speed

(b) to increase its speed

(c) to decelerate due to friction

(d) to resist any change in its state of motion

Ans. (d) To resist any change in its state of motion.

21. Inertia is the resistance of an object to any change in its state of motion, including a change in direction. Which property is a measure of the body's inertia?

(a) Weight
(b) Density
(c) Volume
(d) Mass

Ans. (d) Mass.

22. If you are sitting in a moving train and you toss a coin which falls behind you, it means that motion of the train is

(a) accelerated
(b) retarded
(c) along circular tracks
(d) uniform

Ans. (a) Accelerated.

23. An object of mass 4 kg is sliding with a constant velocity of 8 m s^{-1} on a frictionless horizontal table. The force required to keep the object moving with the same velocity is

(a) 32 N
(b) 0 N
(c) 2 N
(d) 8 N

Ans. (b) 0 N (No force needed for constant velocity on a frictionless surface).

24. The working of rocket is based on the principle of conservation of:

(a) energy
(b) mass
(c) momentum
(d) velocity

Ans. (c) Momentum.

25. A water tanker filled up to 67% of its height is moving with a uniform speed. If driver suddenly applies the brake, the water in the tank would

(a) move backward
(b) move forward
(c) rise upwards
(d) be unaffected

Ans. (b) Move forward due to inertia of motion.

26. If 10 kg of husk is compared with 8 kg of iron, then iron will have:

(a) more mass and more inertia
(b) less mass and less inertia
(c) less mass and more inertia
(d) more mass and less inertia

Ans. (b) Less mass and less inertia (since 8 kg < 10 kg).

Answer the Following Questions:-

Q27. (a) (i) Define 1 kgf.

(ii) How is it related to the SI unit of force?

(b) How does the distance of separation between two bodies affect the magnitude of the non-contact force between them?

Ans. (a) (i) 1 kgf is the force due to gravity on a mass of 1 kg.
(ii) 1 kgf = 9.8 N (taking $g = 9.8\ m/s^2$).
(b) The magnitude of the non-contact force between two bodies is inversely proportional to the square of the distance between them ($F \propto 1/r^2$). If distance is doubled, force becomes one-fourth.

Q28. What do you mean by 'balanced' and 'unbalanced' forces?

Ans. If the resultant of two or more forces acting together on a body is zero, the forces are called balanced forces. If the resultant is not zero, they are called unbalanced forces.

Q29. What do you mean by a resultant force?

Ans. Resultant force is that single force acting on a body which produces the same effect or acceleration as produced by a number of forces acting simultaneously.

Q30. State Galileo's law of inertia.

Ans. Every body continues in its state of rest or of uniform motion along a straight line unless or until an external force is impressed upon it.

Q31. What is the tendency of the body in the absence of a force?

Ans. In the absence of a force, the tendency of a body is to remain in its state of rest or uniform motion along a straight line.

Q32. A girl is sitting (facing North) in a train moving along east. If the train suddenly stops, in which direction will she experience a force?

Ans. Towards her right hand (East) due to inertia of motion.

Q33. Can a body remain in rest position when external forces are acting on it?

Ans. Yes. A body can remain at rest if the resultant (net force) of all external forces acting on it is zero.

Q34. If the net force acting on a body be zero, will the body remain necessarily in rest position?

Ans. No. It is possible that the body is moving with a constant velocity in a straight line.

Q35. If a force is acting on a moving body normal to the direction of motion, what will be its effect on the speed and direction of the body?

Ans. There will be no change in the speed of the body, but there will be a continuous change in its direction of motion.

Q36. If many forces of different magnitudes are acting on a body in different directions, in which direction will the body be accelerated?

Ans. The body will accelerate in the direction of the resultant (net) force.

Q37. If you are given four blocks of equal volume: wooden block, aluminium block, glass block and iron block, which has the maximum inertia and why?

Ans. Iron block will have maximum inertia because density of iron is highest, so for a given volume, mass of iron block will be maximum. Mass is the measure of inertia.

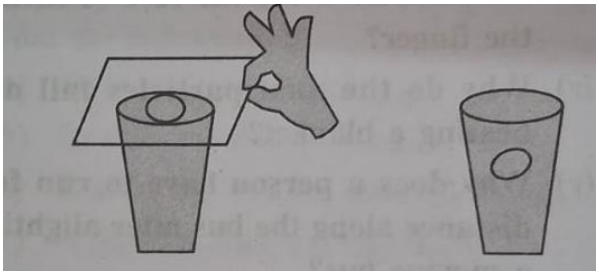
Q38. Explain the following phenomena based on Inertia:

(i) Passengers in a bus fall backward when it starts suddenly.
(ii) A person falls backward when jumping into a moving train.
(iii) A coin drops into tumbler when card under it is flicked.
(iv) Dust particles fall off when a blanket is beaten with a stick.
(v) A person jumping off a moving bus has to run along with it.
(vi) A rider falls forward when a galloping horse stops suddenly.
(vii) An athlete runs a distance before taking a long jump.
(viii) A ball thrown upwards in a moving train returns to thrower's hand.
(ix) Person in a turning car experiences a sideways force.
(x) Stone flies off tangentially when string breaks during whirling.
(xi) Mudguards are provided over bicycle wheels.
(xii) Sparks during knife sharpening fly off tangentially.
(xiii) Sliding doors in train open/close when train starts/stops.
(xiv) Electric fan continues to rotate for some time after switching off.

Ans. (i) Lower body moves with bus; upper body remains at rest due to inertia of rest.

(ii) Feet gain train speed instantly, upper body stays stationary due to inertia of rest.

(iii) Card flies away; coin remains at rest due to inertia of rest and falls down due to gravity.



(iv) Blanket comes into motion; dust particles remain at rest due to inertia of rest and fall off.

(v) Feet touch ground and stop, upper body continues moving forward

due to inertia of motion.

(vi) Lower body stops with horse, upper body continues moving forward due to inertia of motion.

(vii) Gain velocity so inertia of motion helps in covering a longer distance.

(viii) Ball retains forward horizontal velocity of train due to inertia of motion.

(ix) Tendency to continue along straight line due to inertia of direction.

(x) Stone continues in straight line motion along tangent due to inertia of direction.

(xi) Rotating wheel throws mud tangentially due to inertia of direction.

(xii) Sparks move along straight line tangent due to inertia of direction.

(xiii) Doors tend to remain in original state due to inertia of rest or motion.

(xiv) Continues to rotate due to inertia of motion until air resistance and friction stop it.

Q39. What is the purpose of the concept of momentum?

Ans. The concept of momentum measures the quantitative effect of a force.

Q40. What does Newton's second law of motion tell?

Ans. Newton's second law gives the quantitative relationship between force, mass, and acceleration ($F = ma$).

Q41. State Newton's second law of motion.

Ans. Rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of force. $F = m(v - u)/t = ma$.

Q42. Write mathematical form of Newton's

second law of motion. Ans. $F = ma$ (or a

$\propto F/m$). Force = Mass × Acceleration.

Q43. Obtain the relation between newton and dyne.

Ans. $1\ N = 1\ kg \times 1\ m/s^2 = 1000\ g \times 100\ cm/s^2 = 10^5\ g\ cm/s^2 = 10^5$ dynes. Thus, $1\ N = 10^5$ dyne.

Q44. Prove that first law of motion is contained in second law of motion.

Ans. From second law: $F = ma$. If $F = 0$,

then $ma = 0 \Rightarrow a = 0$ (since $m \neq 0$).

Zero acceleration means the body will remain at rest or continue moving with uniform velocity, which is Newton's first law.

Q45. State Newton's third law of motion.

Ans. To every action there is always an equal and opposite reaction: $F_{1\ 2} = -F_{2\ 1}$.

Q46. What is the purpose of Newton's third law?

Ans. Newton's third law defines the nature of force (forces always occur in equal and opposite pairs).

Q47. Do action and reaction act on the same body or on different bodies?

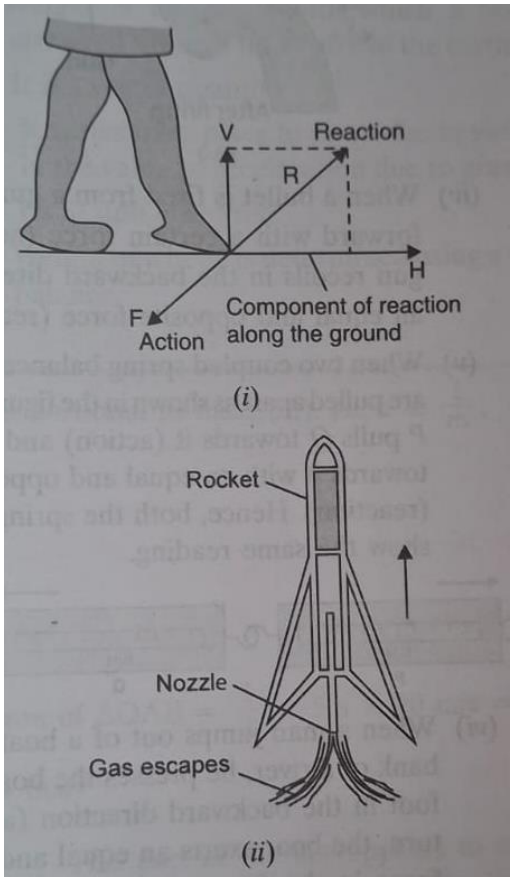
Ans. Action and reaction always act on different bodies.

Q48. Are action and reaction simultaneous?

Ans. Yes, action and reaction act simultaneously.

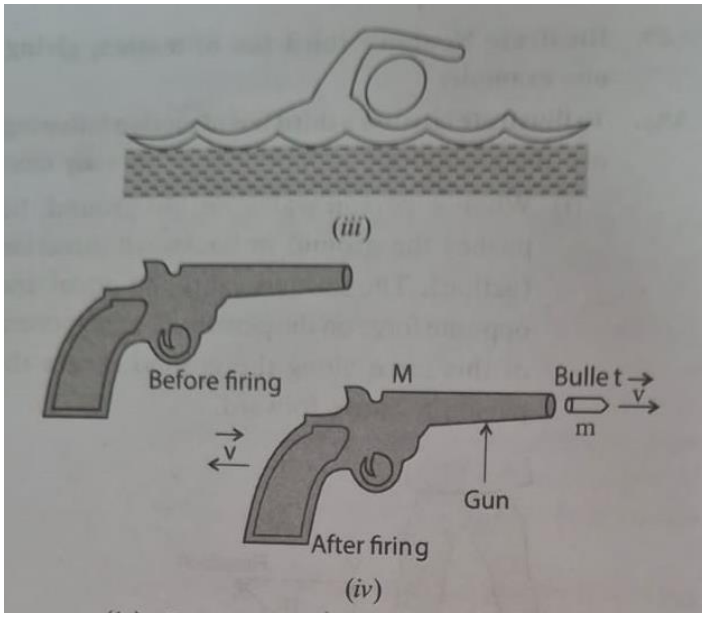
Q49. Illustrate Newton's third law of motion, giving examples.

Ans. (i) Walking: Person pushes ground backward (action); ground pushes person forward (reaction).



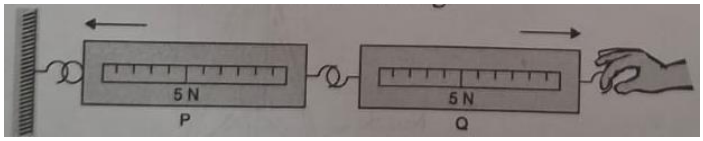
(ii) Rocket / Jet: Hot gases escape downward (action); rocket moves upward (reaction).

(iii) Swimming: Swimmer pushes water back (action); water pushes swimmer forward (reaction).



(iv) Recoil of Gun: Bullet moves forward (action); gun recoils backward (reaction).

(v) Jumping from boat: Man pushes boat backward (action); boat pushes man forward to shore (reaction).



Q50. Mention a few examples in which one body influences the other body without being in contact. Ans. 1. Magnet attracting iron nails.

2. Charged comb attracting small paper bits.

3. Earth pulling a falling object downwards by gravity.

Q51. Why is it difficult to climb up a greasy pole?

Ans. Due to greasy slippery surface, proper backward force (action) cannot be exerted; hence ground/pole cannot offer equal upward push (reaction).

Q52. On a sail boat, air is thrown on the sail from an electric fan attached to the boat. Will the boat start moving?

Ans. No. The fan and boat form an internal system. Air pushes sail forward, but air pushes fan backward equally. Resultant internal force is zero.

Q53. (a) Name the SI unit of: (i) Linear momentum. (ii) Rate of change of momentum.
(b) A body of mass 1.50 kg is dropped from a height of 12 m. What force acts on it during fall? ($g = 9.8\ m/s^2$)

Ans. (a) (i) kg m/s (or N s). (ii) N (or kg m/s^2).
(b) Force = Weight = $mg = 1.50 \times 9.8 = 14.7$ N.

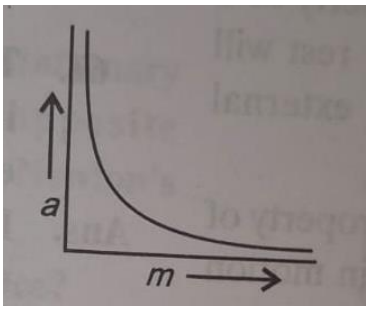
54. Differences between Mass and Weight & Graph Analysis

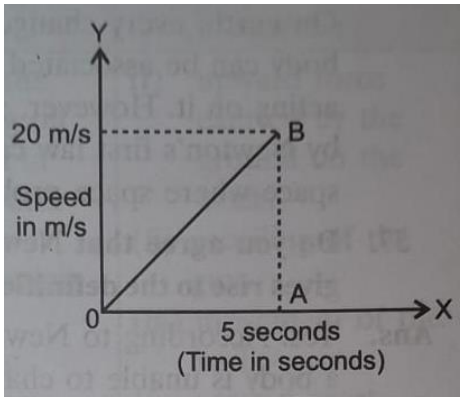
(a) Difference between Mass and Weight:

S.No.	Mass	Weight

1	Quantity of matter contained in a body.	Force with which a body is attracted towards center of earth.
2	It is a scalar quantity.	It is a vector quantity.
3	Remains constant everywhere.	Varies from place to place with value of 'g'.
4	SI unit is kilogram (kg).	SI unit is newton (N).
5	Measured using a beam balance.	Measured using a spring balance.

(b) Relation between acceleration and mass for constant force: $a \propto 1/m$ (Hyperbolic curve).





(c) Speed-time graph calculations (Speed = 20 m/s at t = 5 s from rest):

(i) Distance covered = Area under ΔOAB = 1/2 × base × height = 1/2 × 5 s × 20 m/s = 50 m.

(ii) Acceleration = (v - u) / t = (20 - 0) / 5 = 4 m/s².

55. State Newton's first law of motion. Explain it.

Ans.

According to Newton's first law of motion, everybody in the universe will continue its state of rest or of uniform motion in a straight line, unless an external force acts on it.

This law can be divided into two parts:

(i) Everybody in the universe will continue its state of rest unless an external force is impressed upon it.

This part of the law explains itself that in the universe in everyday life, everyone experiences that if a body is in rest state in a particular direction, it will remain in the state of rest in the same direction unless some external force acts on it.
(ii) Everybody in the universe will continue to remain in the state of uniform motion in a straight line in a particular direction unless some external force impressed upon it.
Hence, it can be inferred that state of motion described by Newton's first law of motion can be experienced in free space where no external force acts.

56. Why does Newton's first law of motion appear to be contradicted in our daily life experiences? Explain.

Ans.

A ball allowed to roll on the floor stops due to the frictional force between the ball and the ground. This part of the law appears to contradict everyday experiences because a moving body always comes to rest after moving a certain distance. However, on its proper analysis you will find that moving bodies on the surface of earth or on any surface come to rest on account of force of friction exerted by air/surface. In the absence of aforesaid force, the body could have continued its motion forever in a straight line.
On earth, every change in uniform motion of a body can be associated with some external force acting on it. However, state of motion described by Newton's first law can be experienced in free space where space probes continue to move.

57. Do you agree that Newton's first law of motion gives rise to the definition of force? If yes, explain.

Ans.

Yes. According to Newton's first law of motion, a body is unable to change its state of rest or of uniform motion in a straight line by itself. Such type of change can be brought only by applying some external force. Further, sometimes external force will tend to change the position of rest or of uniform motion in a straight line.
Thus, it is evident that force is an external agent which changes or tends to change the position of rest or of uniform motion of a body along a straight line. It is the qualitative definition of force.

58. What do you mean by different forms of inertia, i.e. (i) inertia of rest, (ii) inertia of motion and (iii) inertia of direction?

Ans.

(i) Inertia of rest is the inherent property of a body by virtue of which a body at rest will remain at rest unless or until an external force is applied on it.

(ii) Inertia of motion is the inherent property of a body by virtue of which a body in motion continues to remain in motion unless an external force is applied on it.

(iii) Inertia of direction is the inherent property of a body by virtue of which it is unable to change its direction of motion itself.

59. Define momentum of a body. Mention its CGS and SI units.

Ans.

Momentum is the quantity of motion contained in a body. It is defined as the product of mass and velocity.

Momentum (p) = mass (m) × velocity (v)

Its CGS unit is g cm/s and SI unit is kg m/s.

60. Draw the following graphs:

(i) Showing the relation between acceleration and mass for a constant force.

(ii) Showing the relation between acceleration and force for a constant mass.

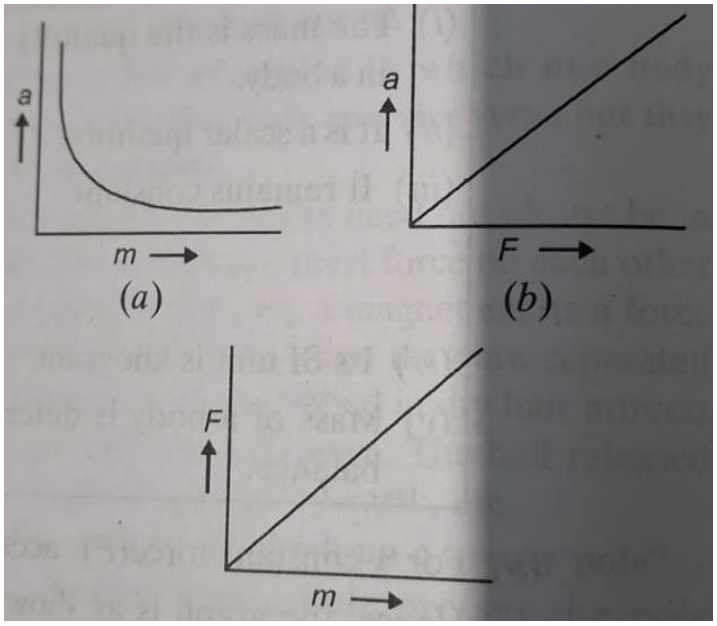
(iii) Showing the relation between force and mass for a constant acceleration.

Ans.

(i) For a constant force (F), acceleration (a) is inversely proportional to mass (m), i.e. $a \propto 1/m$. The graph is, therefore, of the form as shown in (a).

(ii) For a constant mass (m), acceleration (a) is directly proportional to the force (F). Hence, the graph is of the form as shown in (b).

(iii) For a constant acceleration (a), Force (F) is directly proportional to the mass (m). Hence the graph is of the form as shown in (c).



61. Two bodies of masses m_1 and m_2 have the same linear momenta. What is the ratio of their kinetic energies?
Ans.
Let v_1 and v_2 are the velocities of two bodies of masses m_1 and m_2 respectively.
Given: $p_1 = p_2 \Rightarrow m_1 v_1 = m_2 v_2$
$\Rightarrow (m_1 v_1)^2 = (m_2 v_2)^2$
$\Rightarrow m_1^2 v_1^2 = m_2^2 v_2^2$
or $(1/2) m_1 m_1 v_1^2 = (1/2) m_2 m_2 v_2^2$
$\Rightarrow [(1/2) m_1 v_1^2] / [(1/2) m_2 v_2^2] = m_2 / m_1$
$\Rightarrow K_1 / K_2 = m_2 / m_1$

Alternative method:
As $K = p^2 / (2m)$
So, for same p, $K \propto 1 / m$
$\therefore K_1 / K_2 = (1/m_1) / (1/m_2) = m_2 / m_1$

62. Two bodies of masses m_1 and m_2 have equal kinetic energies. What will be the ratio of their linear momenta?
Ans.
Given: $K_1 = K_2$
or $(1/2) m_1 v_1^2 = (1/2) m_2 v_2^2$
or $v_1 / v_2 = \sqrt{(m_2 / m_1)}$
$(m_1 v_1) / (m_2 v_2) = (m_1 / m_2) \sqrt{(m_2 / m_1)}$ {multiplied both sides by m_1 / m_2 }
$p_1 / p_2 = \sqrt{(m_1 / m_2)}$

Alternative method:
Given: $K_1 = K_2$
As $K = p^2 / (2m)$
$p_1^2 / (2m_1) = p_2^2 / (2m_2) \Rightarrow p_1 / p_2 = \sqrt{(m_1 / m_2)}$

63. Answer the following in one word or in one sentence:
(i) What is the relation between the impulse of a force and the change in momentum produced by it?
(ii) If you jump to the shore from a stationary boat, the boat moves in the opposite direction. Does it demonstrate a Newton's law of motion? If yes, which law.
(iii) Can non-living objects exert a force?
Ans.
(i) Impulse of a force = change in momentum
(ii) Yes. Newton's third law of motion
(iii) Yes.

64. State the relationship between force, mass and acceleration. A meteorite burns in the atmosphere before it reaches the earths's surface. What happens to its momentum?
Ans.
Force acting on a body is directly proportional to the product of the mass of the body (m) and the acceleration (a) produced in it, the acceleration taking place in the direction of force, i.e. F = ma. The momentum is transferred to the air molecules and the earth.

65. Mention the action and reaction in the following cases:
(i) a brick lying on the ground
(ii) firing of a bullet from a gun
(iii) a person hammering a nail
(iv) pulling a cart by horse.
Ans.

Action	**Reaction**
(i) Weight of the brick acting on the ground in the downward direction.	(i) Upward force exerted by the ground on the brick.
(ii) Forward motion of bullet.	(ii) Recoiling of the gun.
(iii) Hammering.	(iii) Movement of the nail.
(iv) Horse pushes the ground backwards.	(iv) Ground exerts an equal force in the opposite direction on the feet of horse.

66. State Newton's second law of motion both in words and

in equation form. Under what condition does this equation become F = ma?

Ans.

According to Newton's second law of motion, the rate of change of momentum of a body is proportional to the external force acting on it and is in the direction of force.

$dp / dt \propto F$

$dp / dt = F$ ...(i)

where p stands for momentum and F for the force.

Here, the constant of proportionality is taken as unity since this relation is used to define the unit of force.

If a force F is applied on a body of mass m, the velocity of the body changes in the direction of force, i.e. the acceleration (a) of the body is in the direction of force. Therefore, equation (i) can be expressed in this form, i.e. F = ma, when the mass m of the body remains constant, i.e. does not change with time.

67. What exactly is the mass? Explain the relation between mass and inertia?

Ans.

The mass of a body is the characteristic of that body that relates the body's acceleration to the force causing the acceleration.

Relation between mass and inertia:

Let us consider two balls at rest; one cricket ball of mass m_c and the other light plastic ball of mass m_p, where $m_c > m_p$ .Give a gentle blow to each ball for sometime. Due to equal force the plastic ball attains much greater speed v_p than the cricket ball v_c . The change in velocity of plastic ball is $v_p - 0 = v_p$ and cricket ball is $v_c - 0 = v_c$ and $v_p > v_c$. It clearly shows that the ball with less mass has less resistance to change in speed or change in motion a while. The ball with greater mass has greater resistance to the change in speed or change in motion.

Similarly, if we try to stop the balls moving with the same speed or try to change the direction of motion. It is experienced that more difficult to stop the ball of greater mass m (cricket ball) than the ball of lesser mass m_p (plastic ball). It also shows that resistance is more for greater mass and less for smaller mass. Thus, we can conclude that mass of a body is the measure of its inertia. The greater the mass, the more is the inertia.

68. Obtain the formula F = ma from Newton's second law of motion. In the formula the symbols have their usual meaning.

Ans.

According to Newton's second law of motion, the rate of change of momentum of a body is directly proportional to the force applied and takes place in the direction of force.

Consider a body of mass m whose velocity changes from u to v in time t on applying a force of magnitude F. The magnitude of the initial momentum of the body p_1 = mu. The magnitude of the final momentum of the body p_2 = mv.

Change in momentum of the body (p_2 - p_1) = mv - mu = m(v - u)

Rate of change of momentum = (p_2 - p_1) / t = m(v - u) / t

According to Newton's second law of motion, the magnitude of force

$F \propto (p_2 - p_1) / t = k (p_2 - p_1) / t$

where k is constant of proportionality.

or F = k m (v - u) / t

$\Rightarrow$ F = k m a [acceleration, a = (v - u) / t]

If we choose the unit of force as a unit force, then the unit force will be that force which will produce unit acceleration in a body of unit mass.

i.e. if F = 1 unit, m = 1 unit and a = 1 unit, then

1 = k × 1 × 1 or k = 1

$\therefore$ The equation (i) will be F = ma

or $a \propto F / m$

i.e. the acceleration produced in a body is directly proportional to the force acting on it and inversely proportional to the mass of the body, the acceleration being in the direction of the force applied.

NUMERICAL PROBLEMS :-

Q69. What is the weight of a body of mass 12 kg? What is the force acting on it? ($g = 10\ m\ s^{-2}$)

Ans. Given: m = 12 kg, g = 10 m/s^2

Weight W = mg = 12 × 10 = 120 N.

Force acting on body = Weight = 120 N.

Q70. A body P has a mass of 20 kg moving with 5 m/s. Body Q has mass of 5 kg moving with 20 m/s. Calculate ratio of momentum of P and Q.

Ans. Momentum of P = 20 kg × 5 m/s

= 100 kg m/s.

Momentum of Q = 5 kg × 20 m/s

= 100 kg m/s.

Ratio = 100 / 100 = 1 : 1.

Q71. A car of mass 900 kg running at 72 km h^{-1} is

stopped in 300 m. Find braking force.

Ans. u = 72 km/h = 20 m/s

v = 0

s = 300 m.

$v^2 = u^2 + 2as$

$\Rightarrow 0 = (20)^2 + 2a(300)$

$\Rightarrow a = -400/600 = -2/3$ m/s^2.

Braking Force F = ma = 900 × (2/3) = 600 N.

Q72. How long would a force of 30 N act on a body of mass 10 kg so that it gains velocity of 24 m s^{-1}?

Ans. F = 30 N, m = 10 kg, u = 0, v = 24 m/s.

F = m(v - u)/t

$\Rightarrow 30 = 10(24 - 0)/t$

$\Rightarrow t = 240 / 30 = 8$ s.

Q73. A truck of mass 8 metric tonnes starts from rest and rolls down a hill, traveling 400 m in 20 s. find acceleration and force.

Ans. m = 8000 kg, u = 0, s = 400 m, t = 20 s.

$s = ut + 1/2\ at^2$

$\Rightarrow 400 = 0 + 1/2\ a\ (20)^2$

$\Rightarrow 400 = 200\ a$

$\Rightarrow a = 2$ m/s^2.

Force F = ma = 8000 × 2 = 16,000 N.

Q74. What force is required to accelerate a body of mass 20 kg

from 1.5 m s^{-1} to 9 m s^{-1} in 1/3 of a minute?

Ans. m = 20 kg,

u = 1.5 m/s,

v = 9 m/s,

t = 20 s.

F = m(v - u)/t = 20 × (9 -1.5)/20 = 7.5 N.

Q75. A force of 4 kg,wt acts upon a body of mass 9.8 kg.

Calculate acceleration (g = 9.8 m s^{-2}).

Ans. F = 4 kg wt = 4 × 9.8 N, m = 9.8 kg.
a = F / m = (4 × 9.8) / 9.8 = 4 m/s^2.

Q76. A bullet of mass 0.005 kg travelling at 150 m s^{-1} penetrates a fixed wooden block for 0.1 s. Calculate penetration distance and retarding force.

Ans. m = 0.005 kg, u = 150
m/s, v = 0, t = 0.1 s

v = u + at

⇒0 = 150 + a(0.1)

⇒a = -1500 m/s^2.

Retarding force = ma

= 0.005 × 1500 = 7.5 N.

Distance s = (v^2 - u^2)/(2a)
= (0 - 22500) / (-3000)
= 7.5 m.

Q77. A force of 8 N gives m_1 acceleration of 8 m s^{-2} and m_2 acceleration of 24 m s^{-2}. What acceleration if both masses tied together?

Ans. m_1 = F/a_1

= 8/8 = 1. kg

m_2 = F/a_2

= 8/24 = 1/3 kg.

Total Mass m = 1 + 1/3 = 4/3 kg.
Combined Acceleration a = F / m = 8 / (4/3) = 6 m/s^2.

CHAPTER- HEAT AND ENERGY

SECTION - A

Multiple Choice Questions:-

1. Choose the correct statement from the following:

(a) Heat flows; temperature decides direction

(b) Temperature flows; heat decides direction

(c) Heat decides direction

(d) Heat flows cold to hot

Ans. (a) Heat is the thermal energy in transit, whereas temperature determines direction of heat flow (hot to cold).

2. Gas enclosed in jar. As temperature increases:

(a) Pressure decreases

(b) Molecules collide with each other & walls more often

(c) Pressure higher at top

(d) Molecules move slower

Ans. (b) Kinetic energy increases with temperature, leading to more frequent and energetic collisions.

3. Amount of heat energy contained by an object depends on:

(a) Volume only

(b) Mass only

(c) Temperature only

(d) Mass, temperature and nature of material

Ans. (d) Heat energy $Q = m \cdot c \cdot \Delta T$ depends on mass (m), specific heat capacity/nature (c), and temperature (T).

4. Anomalous expansion of a substance is:

(a) Expansion on cooling in a certain temperature

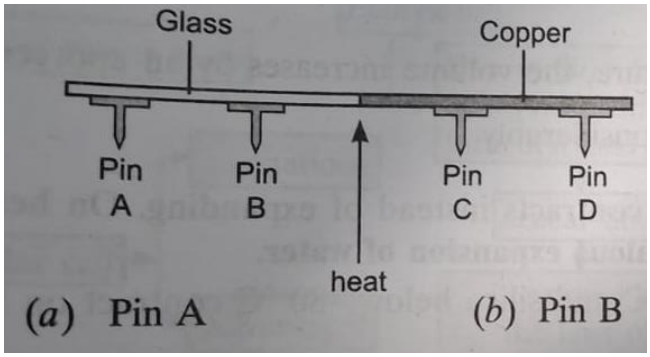
(b) Contraction on cooling in certain range

Range

(c) Contraction on cooling always (d) Expansion on heating

Ans. (a) Expansion of a substance on cooling within a specific temperature range (e.g., water between 4
°C and 0 °C).

5. 1m rod half glass half copper with wax pins A, B (copper) & C, D (glass). Heated in center. Which pin falls first?



(a) Pin A (b) Pin B
(c) Pin C (d) Pin D

Ans. (c) Pin C (or Pin B closest to heating center on copper side). Copper is a much better conductor of heat than glass, so wax melts fastest on copper side nearest center.

6. Anomalous expansion of water is:

(a) Expansion when heated 4°C to 10°C (b) Expansion when cooled 4°C to 0°C
(c) Contraction when cooled 4°C to 0°C (d) Contraction when heated 4°C to 10°C

Ans. (b) Expansion of water when cooled from 4 °C to 0 °C.

7. SI unit of heat is:

(a) erg (b) J
(c) J/kg (d) cal

Ans. (b) Joule (J).

8. Choose physical quantity whose unit is calorie:

(a) Work
(b) Heat
(c) Temperature
(d) Volume

Ans. (b) Heat.

9. 1 Joule is equal to:

(a) 1 cal
(b) 4.18 cal
(c) 0.24 cal
(d) 1 kcal

Ans. (c) 0.24 calories (since 1 cal = 4.184 J).

10. Choose SI unit of temperature:

(a) Fahrenheit
(b) Joule
(c) Kelvin
(d) Celsius

Ans. (c) Kelvin (K).

11. When water is cooled from 4 °C to 0 °C it:

(a) First contracts, then expands
(b) Contracts
(c) Expands
(d) First expands, then contracts

Ans. (c) Expands (anomalous expansion).

12. On converting 21 °C, 39 °C, and 56 °C to Kelvin scale:

(a) 294 K, 322 K, 329 K
(b) 296 K, 278 K, 349 K
(c) 294 K, 312 K, 339 K
(d) 294 K, 312 K, 329 K

Ans. (d) $T(K) = t(°C) + 273 \Rightarrow 21+273=294$ K, $39+273=312$ K, $56+273=329$ K.

13. If a liquid is heated from 30 °C to 85 °C its volume:

(a) Decreases
(b) Remains same
(c) Increases
(d) May decrease

Ans. (c) Increases due to thermal expansion.

14. Temperature at which density of water is maximum:

(a) 273 K
(b) 277 K
(c) 373 K
(d) 288 K

Ans. (b) 277 K (which corresponds to 4 °C).

15. Choose correct statement about water density:

(a) 0 to 4°C density decreases
(b) Cooled 0 to -4°C increases
(c) Heated 0 to 4°C density increases, then decreases above 4°C to 10°C
(d) Heated 0 to 10°C increases

Ans. (c) Density of water increases from 0 °C to 4 °C (reaching max 1 g/cm^3) and then decreases above 4 °C.

16. Anomalous expansion of water is responsible for:

(a) Bursting of pipelines in winter
(b) Damage to crops during cold nights
(c) Preserving aquatic life in frozen lakes
(d) All of the above

Ans. (d) All of the above.

17. Choose a substance which expands on heating:

(a) Silver iodide (80°C to 141°C)
(b) Iron
(c) Water (0°C to 4°C)
(d) Silica below -80°C

Ans. (b) Iron expands normally upon heating

Answer the following questions:-

18. **What do you mean by heat?**

Ans. Heat is a form of energy that flows from one body to another due to a temperature difference between them.

19. **How can you say that heat is a form of energy?**

Ans. According to kinetic theory, heating a body increases the kinetic energy of its constituent molecules (e.g., converting ice to water and water to steam). Since supplying heat increases molecular mechanical energy, heat is a form of energy.

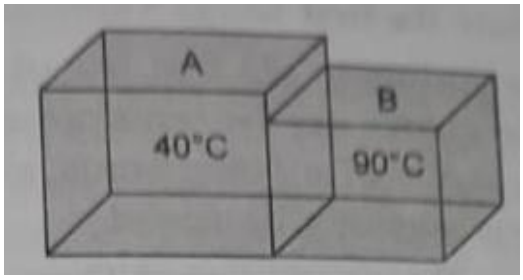
20. **What do you mean by internal energy of a body?**

Ans. Internal energy is the total sum of kinetic energy (due to molecular motion) and potential energy (due to intermolecular forces) of all constituent atoms/molecules of a body.

21. **Name the factor on which heat flow between two bodies depends - quantity of heat or temperature difference.**

Ans. Temperature difference determines direction of heat flow (always from higher to lower temperature).

22. **Two blocks A (40 °C) and B (90 °C) are placed in contact. From which block will heat flow?**



Ans. Heat will flow from block B (90 °C) to block A (40 °C).

23. **When do we say two objects are in thermal equilibrium?**

Ans. When two contact objects reach the same temperature and no net heat exchange occurs between them.

24. **Is 'touching' a proper method to measure hotness? Explain.**

Ans. No. Sensation of touch is relative and depends on initial hand temperature. Warm water feels cold to a hot hand and warm to a cold hand.

25. **What do you mean by thermal expansion?**

Ans. The increase in size (length, area, or volume) of a substance when its temperature is increased.

26. **State the First Law of Thermodynamics.**

Ans. Energy can neither be created nor destroyed; it can only be transformed from one form to another. Total energy remains conserved.

27. **State the Second Law of Thermodynamics.**

Ans. During energy transformation, some energy is inevitably degraded into unrecoverable thermal energy (entropy increases), though total energy remains conserved.

28. **Explain thermal expansion based on Kinetic Theory.**

Ans. Heating increases kinetic energy and vibration amplitude of molecules, increasing average inter-molecular separation, causing macroscopic expansion.

29. **What do you understand by temperature?**

Ans. Degree of hotness or coldness of a body; a measure of average translational kinetic energy per molecule.

34. Why is the scale on a clinical thermometer restricted to 35 °C to 42 °C?

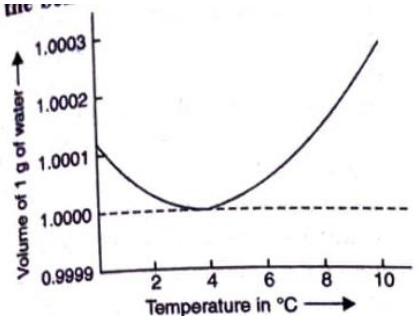
Ans. Human body temperature fluctuates only within a narrow range around normal (37 °C). Restricting scale allows compact design with high accuracy.

Q35. Differences between Heat and Temperature:

Feature	Heat	Temperature
Definition	Form of energy flowing due to temperature difference	Measure of degree of hotness or coldness
Molecular Basis	Total kinetic energy of molecules	Average kinetic energy of molecules
Cause / Effect	Heat is the cause	Temperature is the effect
SI Unit	Joule (J)	Kelvin (K)

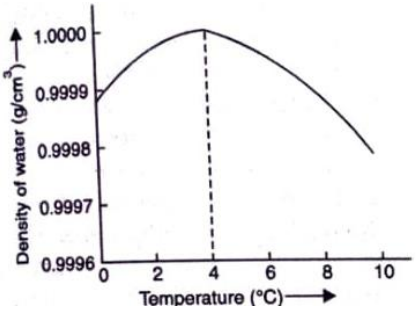
36. If a given mass of water is heated from 0 °C to 10 °C sketch the temperature-volume graph to show the behaviour of water.

Ans.



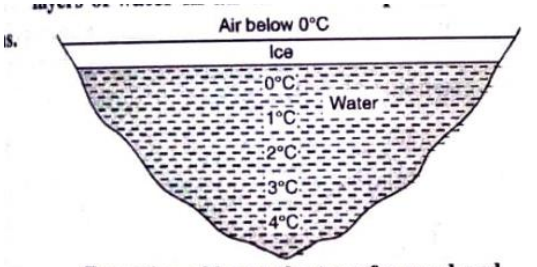
37. Draw a graph showing the variation of density of water with temperature.

Ans.



38. Draw a diagram to show the temperature of various layers of water in an ice-covered pond.

Ans.



Formation of ice at the top of a pond and temperature variation of various layers in water

39. (i) Why do water pipes burst during severe frost?
(ii) Why are taps left dripping in sub-zero temperature during extremely cold season?
(iii) Why are exposed water pipes lagged with straw in winter in hilly areas?
(iv) Why does a glass bottle completely filled with water and tightly capped burst, when placed in freezer of a refrigerator?
(v) Why are soft drink bottles not filled completely?
(vi) Why do fruits and vegetables get damaged during severe frost?
(vii) Why are hilly rocks burst during severe frost?

Ans.

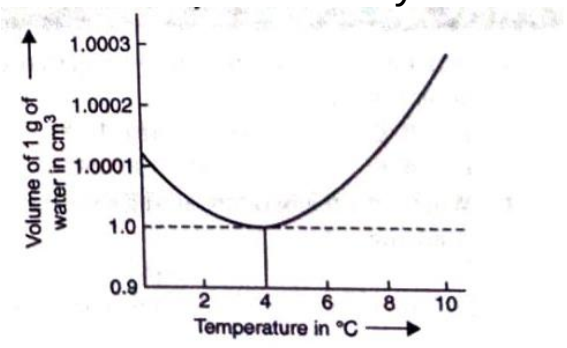
Ans. (i), (ii) Water pipelines often burst during severe frost because water freezes at sub-zero temperature and expands. Since there is no space in the pipes for the expansion of freezing water, therefore, it exerts large pressure on the pipes, thereby bursting them. That is why, people leave their taps dripping at night so as to provide enough space for the expansion of freezing water.
(iii) To check the transfer of heat of water in the pipes to the surroundings, people in hilly regions lag the exposed water pipes with

straw. This helps in maintaining the water temperature above 0 °C. Hence water is saved from freezing.
(iv), (v) As the water expands with the temperature falling below 4 °C. In the freezer, the water in the glass bottle freezes and expands, when the bottle is tightly capped so it will not get space to expand and bottle will burst. That is why the soft drink bottles are not filled completely.
(vi) Fruits and vegetables or plants get damaged in severe cold because water present in plant cells expands on freezing and bursts the cells.
(vii) During severe frost, the water in the cracks of hilly rocks freezes and due to volume expansion the freezed water exerts tremendous pressure on the rocks and burst them.

40. What do you mean by anomalous expansion of water?

Ans.

On heating some substances, instead of expanding, contract over a certain range of temperature. Water is an example. If we take some amount of water at 0 °C and start heating it, water contracts instead of expanding over the temperature range 0 °C to 4 °C. On heating above 4 °C, the volume of water further increases. Now if water above 4 °C is cooled, it contracts till the temperature of water reaches 4 °C and on further cooling below 4 °C, its volume increases instead of decreasing. The expansion of water, when it is cooled from 4 °C and 0 °C is known as anomalous expansion of water. Thus, water has its least volume and maximum density at 4 °C.



SECTION - B

Multiple Choice Questions

1.Choose a non-renewable source of energy from the following:

(a) Fossil fuels

(b) Sun

(c) Wood

(d) Wind

Ans. (a) Fossil fuels

2.In thermal power plant, fuel used is:

(a) uranium

(b) fossil fuels

(c) biomass

(d) water

Ans. (b) fossil fuels

3.The ultimate source of energy for all ecosystems is:

(a) wind

(b) wood

(c) sun

(d) water

Ans. (c) sun

4.Renewable source of energy is:

(a) fossil fuels

(b) coal

(c) natural gas

(d) sun

Ans. (d) sun

5.The list contains three energy resources P, Q and R:
P - sunlight on solar panels | Q - nuclear fission in reactors | R - geothermal energy from hot rocks Which of these resources are renewable?

(a) P and Q only

(b) Q and R only

(c) P and R only

(d) P, Q and R

Ans. (c) P and R only

6.Choose the form of energy from the following which leads to least environmental pollution in the process of its harnessing and utilisation:

(a) Nuclear energy

(b) Thermal energy

(c) Solar energy

(d) Geothermal energy

Ans. (c) Solar energy

7.Ocean thermal energy is due to:

(a) energy stored by waves in the ocean

(b) pressure difference at different levels

(c) temperature difference at different levels

(d) tides arising out

Ans. (c) temperature difference at different levels

8.Select the correct row showing sources reliably available / not available at all times:

(a) Available: Geothermal | Not available: Nuclear fission, solar

(b) Available: Geothermal, nuclear fission | Not available: Solar

(c) Available: Solar, nuclear fission | Not available: Geothermal

(d) Available: Solar | Not available: Nuclear fission, geothermal

Ans. (b)

9.Choose the correct alternative from the following two statements: Statement I: Heating capacity of biogas is more

than that of biomass. Statement II: Biogas produces lesser pollution as compared to biomass.

(a) I is true, II is false

(b) I is false, II is true

(c) Both I and II are true

(d) Both I and II are false

Ans. (c) Both I and II are true

Explanation: High calorific value and carbon-neutral production make biogas cleaner and more efficient.

10. The main constituent of biogas is:

(a) hydrogen

(b) carbon dioxide

(c) hydrogen sulphide

(d) methane

Ans. (d) methane

11. Biogas is formed in the:

(a) presence of water only

(b) presence of air only

(c) presence of air and absence of water

(d) presence of water and absence of air

Ans. (d) presence of water and absence of air

12. Choose one of the following which is NOT correct for biogas:

(a) it is carbon neutral

(b) it is non-renewable

(c) it depends on micro-organisms

(d) it yields rich manure

Ans. (b) it is non-renewable

13. **Biogas is a better fuel than animal dung cake because:**
(i) Biogas is a renewable source (ii) Dung cake has higher calorific value
(iii) Biogas has high heating capacity (iv) Biogas burns without smoke

(a) (i) only

(b) (ii) only

(c) (iii) and (iv)

(d) (i) and (ii)

Ans. (c) (iii) and (iv)

14. **Biogas is a mixture of the following gases:**

(a) Ethane, Carbon monoxide, Nitrogen and Butane

(b) Methane, Hydrogen, Carbon dioxide and Nitrogen

(c) Butane, Carbon monoxide, Propane and Hydrogen

(d) Carbon monoxide, Sulphur dioxide and Hydrogen

Ans. (b) Methane, Hydrogen, Carbon dioxide and Nitrogen

15. **Choose the raw material used in biogas plant:**

(a) Animal dung

(b) Crop residue

(c) Food waste

(d) All of the above

Ans. (d) All of the above

16. **Choose the name of the greenhouse gas from the following:**

(a) nitrogen

(b) oxygen

(c) carbon dioxide

(d) chlorine

Ans. (c) carbon dioxide

17. Select the effect of increase of carbon dioxide gas in atmosphere:

(a) no change in temperature

(b) increase in humidity

(c) increase in temperature

(d) decrease in temperature

Ans. (c) increase in temperature

18. In the absence of greenhouse gases in atmosphere, the average temperature of earth's surface would have been:

(a) 273 K

(b) 255 K (-18°C)

(c) 288 K (15.5°C)

(d) 306 K

Ans. (b) 255 K

19. Choose the effect of global warming:

(a) decrease in human deaths

(b) decrease in sea levels

(c) increase in yield of crops

(d) increase in sea levels

Ans. (d) increase in sea levels

20. Choose the right combination of terms which has no fossil fuel:

(a) Kerosene, wind and tide

(b) Wind, wood, sun

(c) Petroleum, wood, sun

(d) Wind, ocean and coal

Ans. (b) Wind, wood, sun

21. Acid rain happens because:

(a) burning of fossil fuels release oxides of carbon, nitrogen and sulphur

(b) sun leads to heating of upper atmosphere

(c) earth atmosphere contains acids

(d) electrical charges produced in clouds

Ans. (a)

22. Choose the main constituent of biogas from the following:

(a) hydrogen sulphide

(b) methane

(c) carbon dioxide

(d) hydrogen

Ans. (b) methane

23. The power generated in a windmill:

(a) depends on height of tower

(b) depends on wind velocity

(c) increased by planting tall trees

(d) more in rainy season

Ans. (b) depends on wind velocity

24. Choose the correct option for depletion of Ozone layer:

(a) excessive deforestation

(b) excessive use of automobiles

(c) excessive use of fluorine and chlorine contained man-made

compounds

(d) excessive industrial units

Ans. (c)

25. What are the main measures to minimize the impact of global warming?

(a) Policy measures

(b) Technological measures

(c) Economic measures

(d) All of the above

Ans. (d) All of the above

26. IEA is the acronym of:

(a) Indian Eco Academy

(b) International Energy Agency

(c) Indian Energy Association

(d) International Eco Academy

Ans. (b) International Energy Agency

Answer the Following Questions

27. Define natural resources.

Ans. Natural resources are living or non-living substances available in the normal environment, which are being exploited for supporting life and meeting human requirements.

28. Name any two renewable and two non-renewable natural resources.

Ans. Renewable resources: Forests and groundwater (if balance is

maintained). Non-renewable resources: Fossil fuels and metallic minerals.

29. What do you mean by 3-R strategy?

Ans. 3-R strategy means Reduce, Recycle, and Reuse natural resources.

30. What are hot spots of biodiversity?

Ans. Biodiversity hot spots are areas rich in biodiversity that have been declared sensitive due to human interference.

31. Expand the following abbreviations:
(i) IUCN (ii) WWF (iii) UNEP (iv) WCS (v) CITES

Ans. (i) IUCN: International Union for Conservation of Nature and Natural Resources
(ii) WWF: World Wildlife Fund
(iii) UNEP: United Nations Environment Programme
(iv) WCS: World Conservation Society
(v) CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

32. State the measures to conserve natural resources.

Ans. (i) Sparingly use non-renewable resources like coal, petroleum, and gas.
(ii) Extend mineral life spans through recycling, substitution, and synthesis.
(iii) Discover alternative energy sources.
(iv) Use renewable resources at replenishment rates (e.g., groundwater vs. rainfall).

33. What do you mean by silviculture?

Ans. Silviculture means the cultivation of forest trees, aimed at replenishing forests.

34. Mention the advantages of silviculture.

Ans. (i) Maintains water cycle in nature.
(ii) Prevents floods and soil erosion.
(iii) Produces larger quantities of industrial raw materials.
(iv) Helps conserve wildlife.

35. State the adverse effects of deforestation.

Ans. Deforestation destroys plants, animals, and microorganisms, while increasing the greenhouse effect and global warming.

36. Define oil slick.

Ans. A thin film formed on the surface of water due to oil spilt or offloaded from oil tankers in the sea.

37. What is the effect of oil slick on aquatic life?

Ans. Aquatic plants and animals die due to lack of oxygen.

38. What is groundwater table?

Ans. The depth in the soil below which all pore spaces are saturated with water.

39. Effect of excessive nitrogen compounds carried to a pond during heavy rains?

Ans. It enhances algal/aquatic plant growth (eutrophication), leading to oxygen depletion and fish deaths in the long run.

40. Cause of trees drying up near industries excessively using tube wells?

Ans. Excessive groundwater extraction lowers the water table beyond the reach of tree roots.

41. List measures taken for replenishment of groundwater.

Ans. Build dams, tanks, and ponds; practice rainwater harvesting; terrace hillsides; create field bunds and contour trenches.

42. Importance of oceans for human welfare?

Ans. Oceans are rich sources of animals, sea plants, minerals, and algae essential for human welfare.

43. Name any two natural cycles of material.

Ans. (i) Water cycle, (ii) Carbon cycle, (iii) Nitrogen cycle.

44. Name four important biogeochemical cycles in nature.

Ans. Carbon cycle, Nitrogen cycle, Oxygen cycle, and Water cycle.

45. What is bioenergy? State its source.

Ans. Energy obtained from biomass. The primary source is solar energy (~1%) absorbed by plants via photosynthesis.

46. Example of resource exploitation causing environmental damage?

Ans. Mining metals produces large quantities of discarded slag per tonne extracted, causing land and water pollution.

47. Why management of natural resources requires long term perspective?

Ans. To ensure resources last for future generations rather than being depleted for short-term gains.

48. Define solar energy.

Ans. Energy obtained directly from the Sun.

49. Three components of sunlight & component used in heating devices?

Ans. (i) Ultraviolet radiation, (ii) Visible light,

(iii) Infrared radiation. Infrared radiation is responsible for heating.

50. Characteristics of good energy sources?

Ans. (i) High energy yield per unit mass/volume.
(ii) Convenient to use.
(iii) Economical.
(iv) Easy to store and transport.

51. Wavelength range of visible light?

Ans. 400 nm to 800 nm.

52. Name three solar energy devices.

Ans. (i) Solar cooker, (ii) Solar water heater, (iii) Solar cell.

53. Estimating solar constant value?

Ans. Estimated by solar radiation received per unit area exposed perpendicularly at the average Sun-Earth distance.

54. Physical changes in nature induced by solar energy trapping?

Ans. Winds/storms, ocean waves, evaporation, rainfall, and snowfall.

55. Two ways of harnessing solar energy?

Ans. (i) Collecting as heat.
(ii) Converting directly to electricity via photovoltaic cells.

56. Advantages of solar energy?

Ans. (i) Renewable and inexhaustible.
(ii) Clean, pollution-free.
(iii) Abundantly available worldwide.

57. Process of energy production in the Sun?

Ans. Nuclear fusion.

58. Elements used in solar cells?

Ans. Silicon and Germanium.

59. What is tidal energy?

Ans. Energy possessed by rising and falling water levels during ocean tides.

60. How is tidal energy harnessed?

Ans. By building dams across narrow openings to the sea, where water turns turbines to generate electricity.

61. How is nuclear energy generated?

Ans. In nuclear fission, heavy nuclei (e.g., Uranium) bombarded with low-energy neutrons split into lighter nuclei, releasing immense energy.

62. Limitations of moving water energy?

Ans. (i) Requires continuous large volumes of water.
(ii) Natural waterfalls are geographically restricted.

63. What is hydro energy?

Ans. Energy obtained from flowing water.

64. Three uses of flowing water energy?

Ans. (i) Transporting heavy logs down hilly rivers.
(ii) Irrigation via canals.
(iii) Running watermills.

65. How is flowing water energy harnessed?

Ans. Using water wheels and hydro turbines.

66. Principal advantages of solar cells?

Ans. (i) No moving parts.
(ii) Require minimal maintenance.
(iii) Work efficiently without focusing devices.

67. Why are solar cells expensive despite abundant Silicon?

Ans. Manufacturing requires special-grade (high-purity) Silicon, and silver is used for interconnections.

68. What is wind energy?

Ans. Kinetic energy possessed by air due to its motion. It is a renewable energy source.

69. Principle of a windmill?

Ans. Blowing wind creates a pressure difference across shaped blades, producing a rotational motion that drives an electric generator.

70. Is a single windmill sufficient for commercial power?

Ans. No. Commercial power requires combining the output of many windmills in wind farms.

71. Limitations of wind energy?

Ans. (i) Requires large open spaces with steady wind.
(ii) Needs minimum wind speed (~15 km/h).
(iii) High setup cost and noise pollution.

72. Minimum wind speed required for windmills?

Ans. About 15 km/h.

73. Advantages of wind energy?

Ans. (i) Clean, pollution-free.
(ii) Directly convertible into mechanical/electrical energy.

74. Why use resources carefully?

Ans. (i) Resources are limited.
(ii) Rapid population growth increases demand exponentially.
(iii) Over-exploitation damages ecosystems.

75. Disadvantages of fossil fuels?

Ans. (i) Non-renewable and exhaustible.
(ii) CO_2 causes global warming.
(iii) Acidic oxides (SOx, NOx) cause acid rain.

76. Why search for alternative energy sources?

Ans. Fossil fuels are limited and being rapidly depleted. Alternative renewable sources are necessary for sustainable development.

77. Limitations of ocean energy?

Ans. (i) Few suitable tidal sites.
(ii) Variable wave energy output.
(iii) Low conversion efficiency (3-4% for OTEC).

78. Environmental consequences of increasing energy demand?

Ans. (i) Air pollution from fossil fuels.
(ii) Ecosystem destruction from large dams.
(iii) Bird hazard and noise from wind farms.

79. Steps to reduce energy consumption?

Ans. (i) Choose high-efficiency sources.
(ii) Use energy-saving devices (e.g., pressure cookers).
(iii) Service machinery regularly.
(iv) Adopt energy conservation habits.

80. Explain the water cycle in nature.

Ans. Solar energy evaporates surface water into potential energy of vapor. Vapors form clouds/snow, releasing kinetic energy during rain/melt to feed rivers.

81. Advantages of hydel power over thermal power?

Ans. (i) Cheaper operational cost.
(ii) Pollution-free and renewable.
(iii) Long lifespan (50+ years).
(iv) Multipurpose (irrigation, flood control).

82. Demerits of hydel power projects?

Ans. (i) High initial investment.
(ii) Displaces local populations and submerges land.
(iii) Restricted to specific geographical terrains.

83. What is biomass?

Ans. Living organic matter or its residues, including crops, agricultural waste, sewage, and animal dung. It is a renewable source.

84. Types of biomass fuel?

Ans. (i) Solid: Wood, charcoal, dung cakes.
(ii) Liquid: Ethanol, methanol.
(iii) Gas: Biogas (60% Methane, 40% CO_2).

85. Wind energy definition & source?

Ans. Kinetic energy of moving air, driven primarily by solar heating of the atmosphere.

86. Flow of energy and cycling of minerals in an ecosystem?

Ans. Energy flow is unidirectional (Sun → Producers → Herbivores → Carnivores → Decomposers). Mineral movement is cyclic (Soil → Plants → Animals → Decomposers → Soil).

87. Composition & production of biogas?

Ans. Produced by anaerobic degradation of organic waste. Composed of Methane (up to 75%), CO_2 (25%), and traces of N_2 /H_2 . High calorific value: 55 kJ/g.

88. What is anaerobic degradation?

Ans. Decomposition of organic matter by anaerobic bacteria in the absence of oxygen, yielding biogas.

89. Six advantages of biogas?

Ans. (i) Easy rural setup.
(ii) Smoke-free, clean burning.
(iii) High calorific value (~55 kJ/g).
(iv) Spent slurry forms rich NPK fertilizer.
(v) Hygienic waste disposal.
(vi) Saves forest trees.

90. Difference between Renewable and Non-renewable resources?

Ans. Table below details key differences.

91. Exhaustible vs. Inexhaustible resources?

Ans. Exhaustible resources have fixed reserves (coal, petroleum). Inexhaustible resources have unlimited supply (sun, wind, water).

92. Merits of wind energy?

Ans. (i) Non-polluting.
(ii) Short setup lead time.
(iii) Free and inexhaustible fuel source.

93. Limitations of wind energy?

Ans. (i) Needs steady wind (~15 m/s).
(ii) High capital cost.
(iii) Disturbance to migratory birds.

94. Why is forest replenishment necessary?

Ans. (i) Induces rain.
(ii) Prevents soil erosion and floods.
(iii) Sustains biodiversity and purifies air.

95. Note on mineral resources conservation?

Ans. Minerals are non-renewable and unevenly distributed. Conservation requires recycling, efficient usage, and replacing scarce minerals with abundant alternatives.

96. Is global warming natural?

Ans. No, current accelerated global warming is anthropogenic (human-induced).

97. Primary gas responsible for man-made climate change?

Ans. Carbon dioxide (CO_2).

98. Source & concentration of CO_2 ?

Ans. Pre-industrial level was ~280 ppmv, now exceeding 380+ ppmv due to fossil fuel combustion and deforestation.

99. Cause of atmospheric CO_2 increase?

Ans. Industrial expansion, excessive burning of fossil fuels, and widespread deforestation.

100. Explain the greenhouse effect.

Ans. Trapping of heat by atmospheric gases (or glass/polythene), where shortwave radiation enters easily but longwave re-radiated heat is trapped inside.

101. Why parked cars become hot in the sun?

Ans. Glass windows admit shortwave solar heat, but block re-

radiated longwave heat from interior materials, trapping heat inside

102. Use of water wheel?

Ans. Converts kinetic energy of flowing water into mechanical/electrical energy.

Comparison: Renewable vs Non-Renewable Resources (Q90)

S.No.	Renewable Resources	Non-renewable Resources
(i)	Resources that can be utilized continuously over a long period of time.	Resources that cannot be continuously utilized over a long period.
(ii)	Can be naturally regenerated (e.g., air, water, plants, solar energy).	Cannot be naturally regenerated once exhausted (e.g., coal, petroleum, minerals).

CHAPTER - SOUND

Multiple Choice Questions:-

1. The speed of sound in air at 0 °C is nearly:

(a) 450 m/s (b) 330 m/s
(c) 5100 m/s (d) 1450 m/s

Ans. (b) The speed of sound in air at 0 °C is nearly 330 m/s.

2. Sound propagates in air in the form of:

(a) Longitudinal wave (b) Transverse wave
(c) Both longitudinal and transverse wave (d) Neither longitudinal nor transverse wave

Ans. (a) Sound in air propagates in the form of longitudinal wave.

3. The speed of light in air is:

(a) 3×10^8 m/s
(b) 330 m/s
(c) 3×10^{10} m/s
(d) 5100 m/s

Ans. (a) The speed of light in air is 3×10^8 m/s.

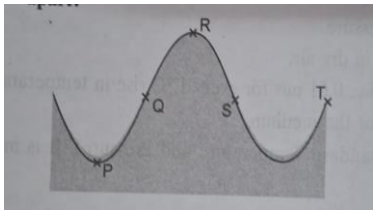
4. A man can hear the sound of frequency:

(a) 1 Hz
(b) 1000 Hz
(c) 200 kHz
(d) 5 MHz

Ans. (b) The audible range of frequency for humans is 20 Hz to 20 kHz. Hence, a man can hear the sound of frequency 1000 Hz.

5. Identify the points shown in the diagram of a wave travelling on the pond which are one wavelength apart?

(a) P and R
(b) Q and T
(c) Q and S
(d) S and T



Ans. (b) Q and T are one wavelength apart as they are at corresponding points in consecutive wave cycles.

6. The properties of ultrasound that make it useful, are:

(a) High power and high speed
(b) High power and good directivity
(c) High frequency and high speed
(d) High frequency and bending around objects

Ans. (b) Properties of ultrasound that make it useful to us are: 1. Energy carried by ultrasound is very high. 2. Travels along a well-defined

straight path with high directivity due to short wavelength.

7. SONAR makes use of:

(a) Infrasonic sound (b)Ultrasound
(c) Ordinary sound (d) Light

Ans. (b) In SONAR (Sound Navigation and Ranging), ultrasound is used to detect and calculate the distance of objects underwater.

8. Choose the correct statement from the following:

(a) Sound and light both require medium for propagation
(b) Sound can travel in vacuum, but light cannot
(c) Sound needs medium, but light does not need medium for its propagation
(d) Sound and light both can travel in vacuum

Ans. (c) Sound needs a medium to propagate and cannot travel in vacuum, whereas light is an electromagnetic wave that can travel in vacuum.

9. Select the correct unit for wavelength from the following:

(a) nm (b) Hz
(c) dB (d) ns

Ans. (a) Wavelength is measured in meters or nanometers (nm).

10. Choose the correct statement about the speed of sound:

(a) It travels fastest in liquids
(b) It travels fastest in a vacuum
(c) It travels fastest in solids
(d) It travels fastest in gases

Ans. (c) Sound travels fastest in solids because elasticity and density properties allow rapid wave transmission.

11. Why do we hear sound when a ball strikes the floor?

(a) Air particles flow into our ears
(b) Wavelength is large enough
(c) Air particles vibrate and produce longitudinal waves
(d) Transverse waves flow through air

Ans. (c) The air particles near the floor vibrate and produce longitudinal waves which reach into our ears through the air.

12. A flash of lightning and thunderclap are detected 5 s apart. Lightning struck 1600 m away. Identify the assumption:

(a) Light travels 320 m/s faster than sound
(b) Sound reaches instantly, light travels at 320 m/s
(c) Light reaches us almost instantaneously, but sound travels at 320 m/s
(d) Thunder emitted 5 s after flash

Ans. (c) Light reaches us almost instantaneously, while sound travels at approximately 320–340 m/s.

13. A star explodes in outer space. Which waves do not reach the Earth?

(a) Intra-red
(b) Sound
(c) Light
(d) Radio

Ans. (b) Sound waves require a material medium and cannot travel through the vacuum of outer space.

14. Choose the true statements for sound from the following:

A. Produced by vibration
B. Speed approx 280 m/s
C. Longitudinal waves

(a) A and C only
(b) B and C only
(c) A and B only
(d) A, B and C

Ans. (a) Sound waves are produced by vibration and are longitudinal waves. (Speed in air is ~330-340 m/s, not 280 m/s).

15. Roshni cannot hear a 10,000 Hz whistle blown by John despite normal hearing. What could be the reason?

(a) Amplitude too large (b) Amplitude too small

(c) Frequency too high (d) Frequency too low

Ans. (b) The sound frequency (10 kHz) is within human audible range, so if she cannot hear it, the amplitude (loudness) must be too small.

16. Speed of sound in air (va), water (vw), and steel (vs). Select descending order:

(a) va > vs > vw (b) va > vw > vs

(c) vw > va > vs (d) vs > vw > va

Ans. (d) Speed of sound is highest in solids (steel), intermediate in liquids (water), and lowest in gases (air): vs > vw > va.

17. Ultrasound travels from muscle into bone at a greater speed. Which change takes place?

(a) Frequency decreases (b) Frequency increases

(c) Wavelength decreases (d) Wavelength increases

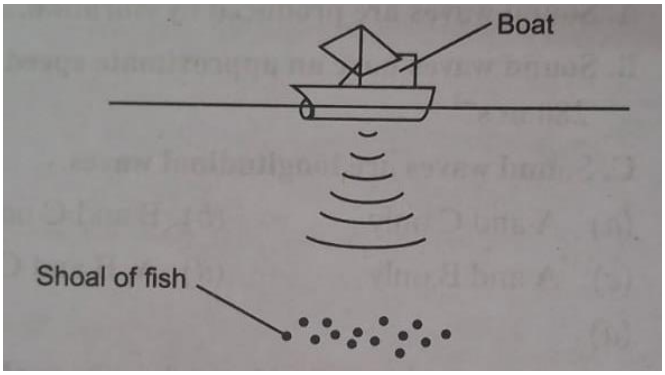
Ans. (d) Frequency remains constant during refraction. Since wave speed V = vλ, an increase in speed causes an increase in wavelength λ.

18. Sound pulse from boat bottom reflects off shoal of fish after 1.4 s. V = 1500 m/s. Depth of shoal:

(a) 525 m (b) 1050 m

(c) 2100 m (d) 4200 m

Ans. (b) Distance d = (V × t) / 2 = (1500 × 1.4) / 2 = 1050 m.



19. Approximate audio frequency range for healthy human ear:

(a) 2 Hz to 2000 Hz (b) 2 Hz to 20000 Hz

(c) 20 Hz to 2000 Hz (d) 20 Hz to 20000 Hz

Ans. (d) 20 Hz to 20,000 Hz.

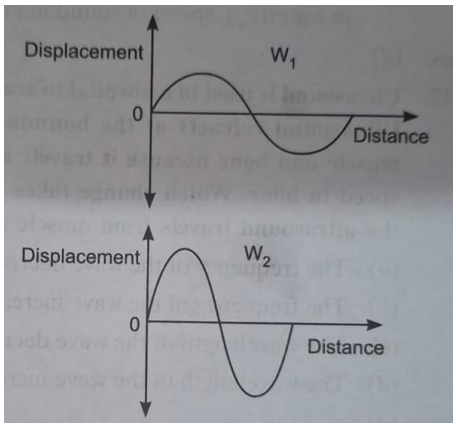
20. Which waves are longitudinal?

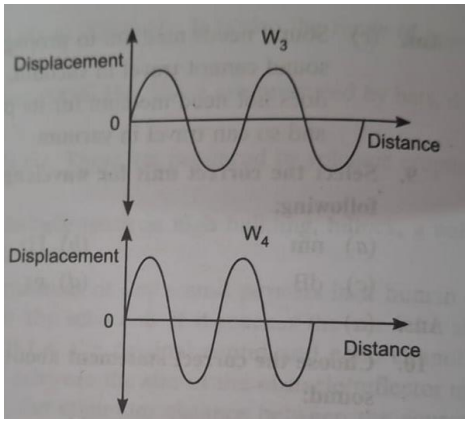
(a) Light waves from a lamp (b) Microwaves in an oven

(c) Water waves on pond surface (d) Sound waves from a trumpet

Ans. (d) Sound waves from a trumpet are longitudinal waves.

21. Comparing four waves W1, W2, W3, W4 on same scale:





(a) Amplitude of W1 = Amplitude of W3

(b) Amplitude of W4 = double of W2

(c) Wavelength of W2 = double of W1

(d) Wavelength of W4 = Wavelength of W2

Ans. (a) Amplitude of wave W1 is equal to the amplitude of wave W3.

22. Adjusting alarm for louder note and higher pitch changes amplitude & frequency to:

(a) Amplitude larger, Frequency larger

(b) Amplitude larger, Frequency smaller

(c) Amplitude smaller, Frequency larger

(d) Amplitude smaller, Frequency smaller

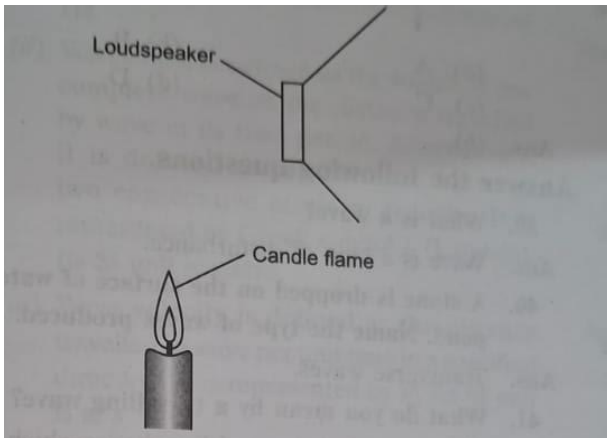
Ans. (a) Loudness depends on amplitude (larger amplitude) and pitch depends on frequency (larger frequency).

23. Stopwatch measurements for sound travel: 0.5s, 0.7s, 0.6s, 0.4s, 0.9s, 0.5s. Value to use:

(a) 0.4 s (b) 0.5 s
(c) 0.6 s (d) 0.9 s

Ans. (c) Mean time t = (0.5 + 0.7 + 0.6 + 0.4 + 0.9 + 0.5) / 6 = 3.6 / 6 = 0.6 s.

24. Flame in front of loudspeaker vibrates. Type of wave and vibration direction:



	Type of wave	Direction of vibration
(a)	Longitudinal	↕
(b)	Transverse	↕
(c)	Longitudinal	↔
(d)	Transverse	↔

Ans. (c) Sound waves are longitudinal; medium particles vibrate back and forth along the direction of wave propagation.

25. Select row with Transverse wave and Longitudinal wave respectively:

(a) Light, Radio (b) Radio, Sound
(c) Sound, X-rays (d) Water, Light

Ans. (b) Radio waves are transverse electromagnetic waves; Sound waves are longitudinal mechanical waves.

26. Jimi counts 9 waves reaching pond side in 6.0 s. Frequency of waves:

(a) 0.16 Hz (b) 0.78 Hz

(c) 1.5 Hz (d) 54 Hz

Ans. (c) Frequency v = Number of waves / Time = 9 / 6.0 = 1.5 Hz.

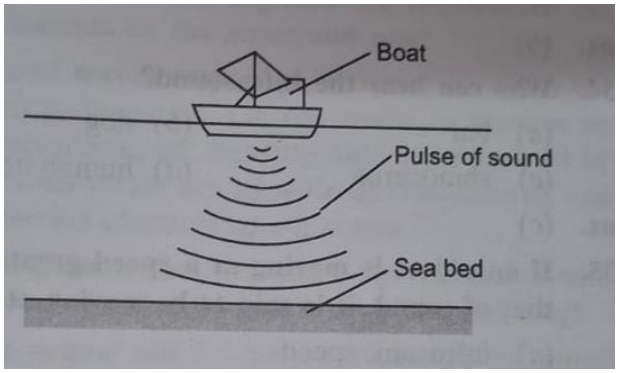
27. Krakatoa eruption sound in 1883 heard 5000 km away. Which statement is NOT correct?

(a) Astronaut in space at 400 km height could hear it (b) People further heard it later

(c) Amplitude was smaller further away (d) Sound was very loud due to large energy

Ans. (a) Sound cannot travel through vacuum, so an astronaut in space cannot hear it.

28. Loudspeaker pulse reflected from 2250 m deep seabed reaches boat in 3.0 s. Speed of sound in sea water:



(a) 330 m/s (b) 750 m/s

(c) 1500 m/s (d) 6750 m/s

Ans. (c) Speed V = (2 × d) / t = (2 × 2250) / 3.0 = 1500 m/s.

29. In SONAR, waves used are:

(a) Ultrasonic (b) Infrasonic

(c) Radio (d) Audible sound waves

Ans. (a) Ultrasonic waves.

30. Sound propagates in air if:

(a) Particles move from one place to another

(b) No moisture in atmosphere

(c) Disturbance moves

(d) Both particles and disturbance move

Ans. (c) Disturbance moves through the medium while medium particles only oscillate about mean positions.

31. If sound changes from feeble to loud, which parameter increases?

(a) Frequency

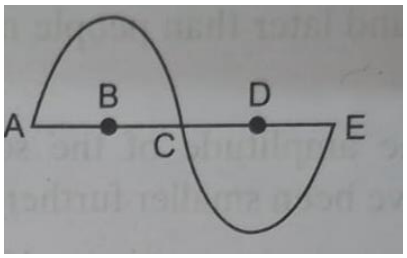
(b)Wavelength

(c) Velocity

(d)Amplitude

Ans. (d) Amplitude determines loudness.

32. In wave curve, half the wavelength is represented by:



(a) AB

(b) BD

(c) DE

(d) AE

Ans. (b) BD represents half of one complete wave cycle (crest to trough).

33. Which kind of sound is produced by earthquake before main shock wave?

(a) Audible sound

(b) Infrasound

(c) Ultrasound

(d) None of above

Ans. (b) Infrasound (< 20 Hz).

34. Who can hear Infrasound?

(a) Bat

(b) Dog

(c) Rhinoceros

(d) Human beings

Ans. (c) Rhinoceroses communicate using infrasound frequencies down to 5 Hz.

35. An object moving faster than speed of sound is moving at:

(a) Infrasonic speed
(b) Sonic speed
(c) Ultrasonic speed
(d) Supersonic speed

Ans. (d) Supersonic speed.

36. In which case sound wave is NOT produced?

(a) Gun fired in room without echoes
(b) Bell ringing under water
(c) Explosion in outer space
(d) Hammer hitting rubber block

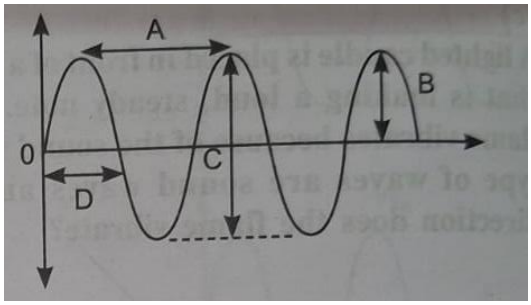
Ans. (c) Explosion in outer space (vacuum prevents sound propagation).

37. If water waves move from shallower to deeper region, its:

(a) Frequency decreases
(b) Wavelength increases
(c) Frequency increases
(d) Wavelength decreases

Ans. (b) Wave speed increases in deeper water while frequency stays constant, so wavelength increases.

38. Arrow marking amplitude of wave in diagram:



(a) A
(b) B
(c) C
(d) D

Ans. (b) Arrow B shows maximum displacement from mean position.

ANSWER THE FOLLOWING QUESTIONS:-

39. **What is a wave?**

Ans. A wave is a periodic disturbance that travels through a medium transmitting energy from one point to another without actual transfer of matter.

40. **A stone is dropped on the surface of water in a pond. Name the type of waves produced.**

41. **Ans.** Transverse waves (ripples on the water surface).

42. **What do you mean by a travelling wave?**

Ans. A travelling (or progressive) wave is a form of disturbance which travels continuously through a medium in a definite direction with a definite velocity due to repeated periodic vibrations of particles about their mean positions, transferring energy without net transfer of mass.

43. **State the requisites of the medium for the propagation of waves.**

Ans. (i) Elasticity: Medium must possess elasticity to return to original state after disturbance.

(ii) Inertia: Medium must possess inertia to store energy.

(iii) Frictionless: Low friction/damping to prevent rapid loss of wave energy.

44. **Define: (i) Frequency (ii) Wavelength (iii) Velocity of a wave.**

Ans. (i) Frequency (ν): Number of complete oscillations/vibrations completed by a particle in one second.

Unit: Hertz (Hz).

(ii) Wavelength (λ): Distance between two consecutive crests/troughs or compressions/rarefactions.

Unit: meter (m).

(iii) Wave Velocity (V): Distance covered by the wave per unit time in a given direction.

Unit: m/s.

45. **Obtain the relation between wave velocity, frequency and wavelength.**

Ans. Let T be the time period.

In time T, the wave travels a distance equal to one wavelength (λ).
Wave velocity V = Distance / Time

= λ / T.

Since frequency f = 1 / T,
substituting gives: V = fλ (Wave Velocity = Frequency × Wavelength).

46. **Explain why a distant lightning flash is seen before thunder is heard.**

Ans. Speed of light in air (3×10^8 m/s) is vastly greater than speed of sound in air (~332 m/s). Light reaches our eyes almost instantaneously, whereas sound takes significant time to cover the distance.

47. **Why can we not hear each other on the moon?**

Ans. Sound waves require a material medium for propagation. Moon lacks an atmosphere (vacuum), so sound waves cannot travel.

48. **If a person strikes one end of a long iron pipe, a listener at the other end hears two sounds. Why?**

Ans. Sound travels through two media: iron pipe and air. Speed of sound in iron (~5000 m/s) is about 15 times faster than in air (~330 m/s). The first sound arrives through iron and the second through air.

49. **Why is sound produced in air not easily heard by a person deep inside water?**

Ans. When sound traveling in air strikes water surface, most of the sound energy is reflected back into air due to large characteristic impedance mismatch between air and water. Very little sound refracts into water.

50. **Why is it possible to detect an approaching distant train by placing ear on railway line?**

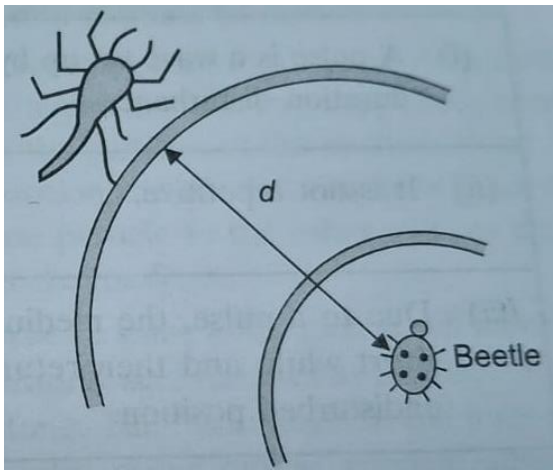
Ans. Sound travels much faster (~5000 m/s) and with significantly less attenuation in solid steel rails than through air (~340 m/s).

51. **What type of hearing aids are required for astronauts on the moon and why?**

Ans. Radio communication devices (transmitters/receivers). Radio waves

are electromagnetic waves which do not require a material medium and travel easily in vacuum.

52. **If a person sets his watch by the sound of a distant siren, will it go fast or slow?**



Ans. The watch will go SLOW. Sound takes finite time to travel from siren to the person. Setting watch upon hearing sound means the watch is set behind actual time by that travel duration.

53. **How does the sand scorpion locate its prey?**

Ans. When a beetle moves on sand, it generates fast longitudinal waves (Vl = 150 m/s) and slower transverse waves (Vt = 50 m/s). The scorpion uses leg sensory receptors to detect the direction from the first-arriving longitudinal wave, and calculates distance d using time delay Δt between wave arrivals: $d = \Delta t \times (Vl \times Vt) / (Vl - Vt)$.

54. **What are mechanical and electromagnetic waves? Give examples.**

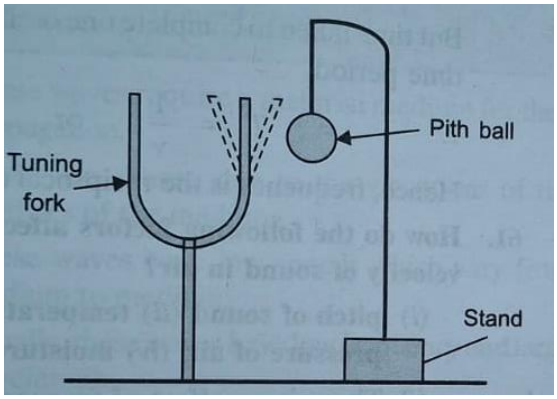
Ans. Mechanical Waves: Require material medium for propagation (e.g., sound waves, water ripples, string vibrations).
Electromagnetic Waves: Do not require medium and travel through vacuum (e.g., light, radio waves, X-rays).

Q54. Difference between Mechanical and Electromagnetic Waves:

Feature	Mechanical Waves	Electromagnetic Waves
Medium Requirement	Requires material medium	Does not require medium (travels in

		vacuum)
Cause	Particle vibrations in medium	Varying electric & magnetic fields
Speed	Low speed (~330 m/s in air, 1500 m/s water)	Very high speed (3×10^8 m/s)
Frequency/Wavelength	Lower frequency, larger Wavelength	Very high frequency, extremely small wavelength
Wave Type	Longitudinal or Transverse	Transverse waves only

56. What is sound? Describe a simple experiment which demonstrates that the sound produced by tuning fork is due to its vibrations.



Ans.

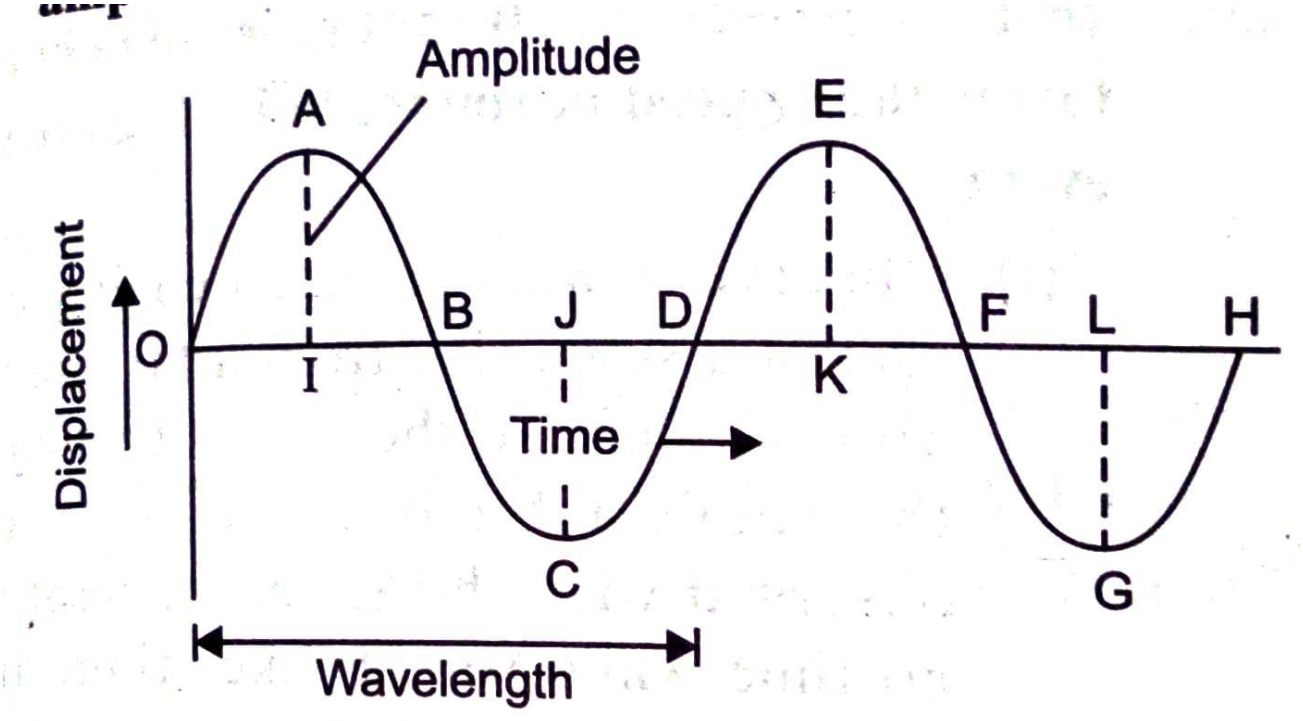
Sound is a form of energy which enables us to have the sensation of hearing.

Experiment to demonstrate sound produced by vibration:

Take a tuning fork, strike it gently against a rubber pad and hold it close to your ear. A sound is heard because sound wave travels through air in the form of compressions and rarefaction. It strikes the eardrum and makes it to vibrate to and fro from where the auditory nerve picks up this motion as a signal and sends it to the brain where these signals are interpreted as sound. Now, take a freely suspended pith ball and touch the same end of tuning fork to it. It is observed that pith ball repeatedly flies outwards. Hence, it is proved that sound is produced due to a vibrating body.

57. Draw a sketch of the variation of the displacement with time for a sinusoidal wave motion and mark amplitude, wavelength, time period on it.

Ans.

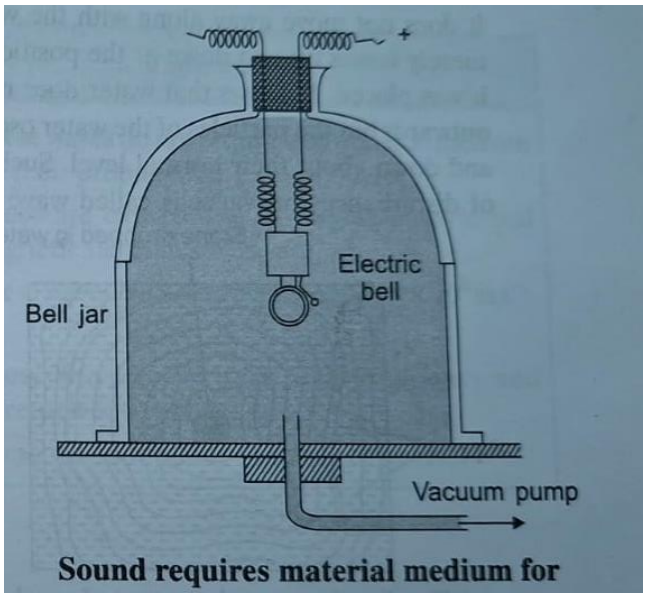


Amplitude is represented by the distance: AI, CJ, EK, GL. Wavelength is represented by the distance: OD, BF, DH, AE, CG.

Time period is represented by the time taken by the wave between the points
(i) O and D (ii) B and F (iii) D and H (iv) A and E (v) C and G.

58. Demonstrate that a material medium is necessary for the propagation of sound.

Ans.



Sound requires material medium for propagation.

A small electric bell is hung inside a glass jar as shown in the following figure.

The jar is connected to a vacuum pump. When the electric bell inside the jar is switched on, the sound produced by it can be heard clearly. Now, pump out the air from the jar. As the air is pumped out from the jar, gradually, the sound of the electric bell becomes slower and slower.

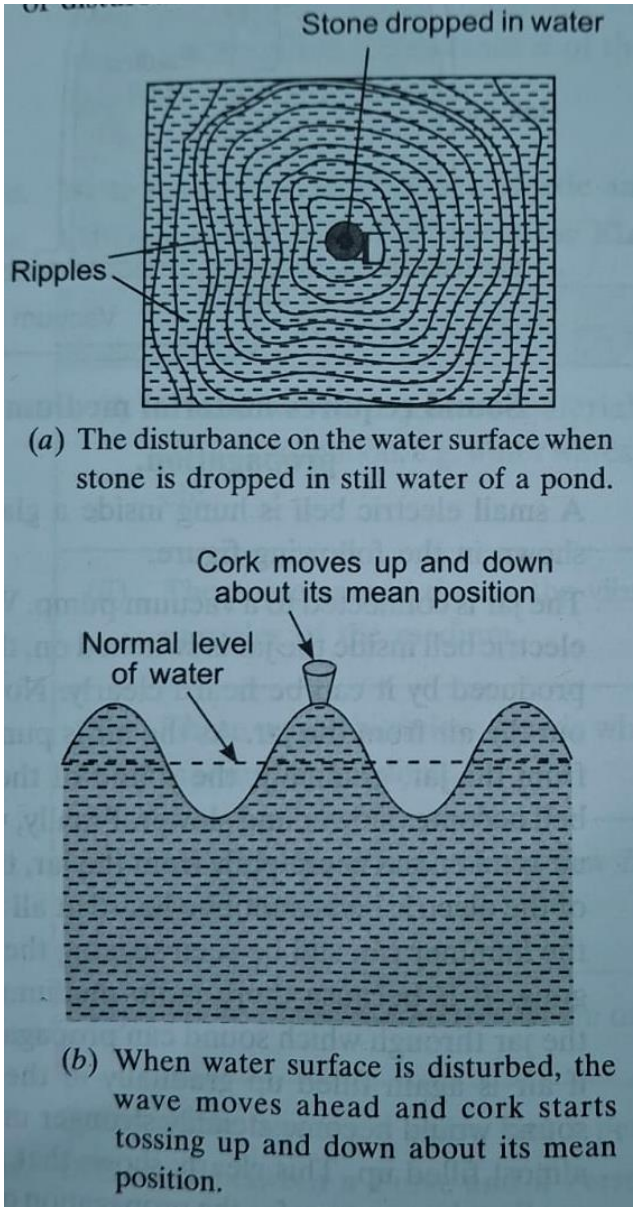
Finally, when the air is taken out completely from the jar, the sound of the electric bell cannot be heard at all although the hammer can still be seen striking the metallic gong. It is because there is no medium (air) in the jar through which sound can propagate. Now, if air is again filled up gradually in the jar, the sound would become steadily stronger until jar is almost filled up. This clearly shows that material medium is necessary for the propagation of sound.

59. What do you mean by wave motion? Explain it with a suitable example.

Ans.

Wave motion is a form of disturbance which travels through a medium due to repeated periodic motion of the particles of the medium about their mean position and the disturbance is handed over from one particle to the other without actual motion of the medium.

When a stone is dropped in still water of a pond, a disturbance is created at the place of dropping the stone. The disturbance in the form of concentric circles, called ripples, spreads outwards from the point of disturbance. Such disturbances which travel are called waves.



(*a*) The disturbance on the water surface when stone is dropped in still water of a pond.

(*b*) When water surface is disturbed, the wave moves ahead and cork starts tossing up and down about its mean position.

If we place a small piece of paper or dry leaf or cork on the surface of water, it is observed that it does not move away along with the wave, but merely tosses up and down at the position where it was placed. It shows that water does not move outwards but the particles of the water oscillate up and down about their normal level. Such motion of disturbances or waves is called wave motion.

60. Define time period and frequency for a wave motion. Hence, obtain their mutual relation.

Ans.

Time period is the time taken by the particle of the medium in completing one oscillation/vibration. It is represented by T. Its SI unit is second.

Frequency is defined as the number of oscillations/vibrations completed by a particle of the medium in one second. Alternatively, it can also be defined as the number of complete wavelengths traversed by wave in one second. It is represented by v (nu). Its SI unit is hertz, represented with unit symbol Hz.

Relation between frequency and time period:

If the frequency of an oscillating body is v, it means it completes v waves in one second.

Hence, time taken to complete v oscillations = 1 s

Time taken to complete one oscillation = (1 / v) s

But time taken to complete one oscillation is called time period, T.

Or T = 1 / v

=> v = 1 / T

Hence, frequency is the reciprocal of time period.

61. How do the following factors affect, if at all, the velocity of sound in air?

(i) pitch of sound (ii) temperature of air, (iii) pressure of air, (iv) moisture of the air.

Ans.

(i) There is no effect of frequency or pitch on the speed of sound.

(ii) Velocity of sound in a gas is directly proportional to the square root of its absolute temperature, i.e. $V \propto \sqrt{T}$. That is velocity of sound in air increases roughly by 0.61 m/s per degree Celsius rise in temperature.

(iii) If the temperature of the gas remains constant, then there is no effect of the pressure change on the speed of sound, $V = \sqrt{(\gamma P/\rho)}$.

(iv) When moisture is present in air, the density of air gets decreased. It is because the density of water vapours is less than that of dry air. Velocity of sound is inversely proportional to the square root of density ($V \propto 1/\sqrt{\rho}$), hence, sound travels faster in moist air than in dry air.

62. Describe two events that demonstrate that light travels much faster than sound.

Ans.

To demonstrate clearly that speed of light is much faster than speed of sound, following are the two events:

(i) Observe a washerman beating a cloth against a stone slab from a far away place. You will observe the action first and hear the sound later because the action is observed with the speed of light within no time while sound takes finite time in travelling through air due to its slow speed.

(ii) If we observe the firing of a canon or blasting of a rock by gun powder, the flash of light/smoke is seen first and, the sound is heard much later. This is because light reaches us almost instantly, whereas the sound takes finite time due to its much slower speed in air.

63. Differentiate between sound waves and light waves.

Ans.

	Sound waves	Light waves
(i)	These waves require a material medium for their propagation.	These waves do not require any material medium for their propagation.
(ii)	These are caused due to the vibrations of the particles of the medium.	These are caused due to varying electric and magnetic fields in space.
(iii)	These waves have low speeds which vary from medium to medium.	These waves have very high speed of 3×10^8 m s^{-1}.
(iv)	Usually, these waves have low frequency and large wavelength.	These waves have very high frequency and extremely low wavelength.
(v)	These waves can be transverse or longitudinal.	These waves are only transverse waves.

64. Differentiate between speed of sound and speed of light.
Ans.

	Speed of sound	Speed of light
(i)	In vacuum speed of sound is zero as it requires material medium for its propagation.	Speed of light is 3×10^8 m/s as it is an electromagnetic wave.
(ii)	Speed of sound in air at STP is 332 m/s.	Speed of light in air at STP is 3×10^8 m/s which is nearly 10^6 times the speed of sound in air.
(iii)	In general, speed, propagation of sound in liquids is greater than that in air. In water speed of sound is about 1480 m/s.	Light does not pass through many dark liquids. In water speed of light decreases than in air. Speed of light in water is 3/4 of that in air, i.e. 2.25×10^8 m/s.
(iv)	In solids, propagation of sound is much more than in gases and liquids. In stainless steel speed of sound is 5800 m/s.	For transparent solids, the speed of light decreases, e.g. it is 2/3 of speed of light in air i.e. $\approx 2 \times 10^8$ m/s. But in opaque solids, speed of light is zero.

Hence, it can be inferred that speed of light is 10^5 to 10^6 times more than the speed of sound in the same medium.

65. Answer the following (in one word or in one sentence):
(i) State three characteristics of the medium required for the propagation of sound.
(ii) What is the effect of density of the medium on the speed of sound?
(iii) The spectators watching the cricket match hear the sound a little later than the batsman actually drives a stroke. Why?
(iv) How does the speed of sound depend on (a) amplitude and (b) wavelength?
(v) To which range of frequencies are the human ears most sensitive?

Ans.

(i) (a) Medium must be elastic.
(b) Medium must have the inertia.
(c) The medium should be frictionless so that there is no loss of energy in propagation.

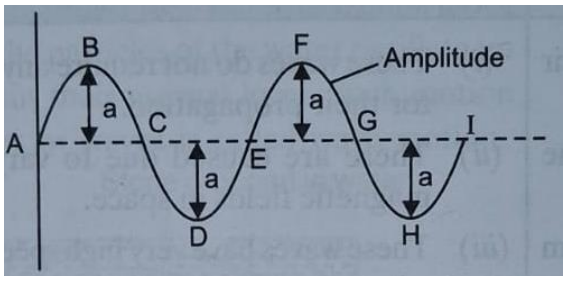
(ii) The speed of sound is inversely proportional to the square root of the density of the medium.

(iii) Action of driving a stroke is observed with the speed of light within negligibly small time while sound takes finite time in travelling through air due to its low speed.

(iv) Speed of sound does not depend on amplitude and wavelength.

(v) 20 Hz to 20,000 Hz.

66. Define the following terms:
(i) amplitude (ii) time period (iii) frequency (iv) wavelength (v) wave number (vi) wave velocity.
Ans.



(i) Amplitude is the maximum displacement of an oscillating particle of the medium of a periodic wave on either side of the mean position. It is represented by 'a' or 'A' and measured in metre. In Fig. particles at B, D, F and H represent the maximum displacement of the particle from the mean position.

(ii) Time period is the time taken by the particle of the medium in completing one oscillation/vibration. It is represented by T. Its SI unit is second.

(iii) Frequency is defined as the number of oscillations/vibrations completed by a particle of the medium in one second. Alternatively, it can also be defined as the number of complete wavelengths traversed by wave in one second. It is represented by v. Its SI unit is hertz, represented with unit symbol Hz.

(iv) Wavelength is defined as the length of one complete wave or the distance travelled by wave in its time period. It is represented by Greek symbol λ (Lambda). Its SI unit is metre.

(v) Wave Number: The reciprocal of wavelength is called wave number, i.e. wave number = $1/\lambda$. Its SI unit is m^{-1}.

(vi) Wave Velocity is the distance travelled by wave per unit time in a specified direction. It is represented by V. Its SI unit is $m\ s^{-1}$.

Numerical Problems:-

67. Calculate frequency of sound wave emitted by bat of wavelength 3.3 mm (V = 330 m/s).

Ans. Given: V = 330 m/s, $\lambda = 3.3$ mm $= 3.3 \times 10^{-3}$ m.

Formula: $V = v\lambda$

$\Rightarrow \nu = V / \lambda = 330 / (3.3 \times 10^{-3})$

$= 100{,}000$ Hz

$= 100$ kHz.

68. In longitudinal wave, time interval between maximum compression and successive maximum rarefaction at 50 Hz:

Ans. Time period $T = 1 / \nu = 1 / 50 = 0.02$ s.

Time between compression and rarefaction $= T / 2 = 0.02 / 2 = 0.01$ s.

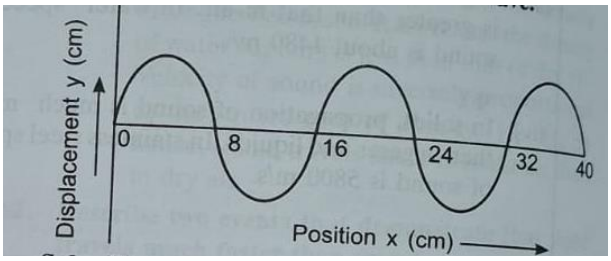
69. A source produces 20 crests and 20 troughs in 0.4 s. Find frequency:

Ans. 20 complete waves in 0.4 s

$\Rightarrow$ Time for 1 wave $(T) = 0.4 / 20 = 0.02$ s.

Frequency $\nu = 1 / T = 1 / 0.02 = 50$ Hz.

70. Wave speed = 12.0 m/s. One complete wave fits in 16 cm (0.16 m). Find wavelength and frequency:



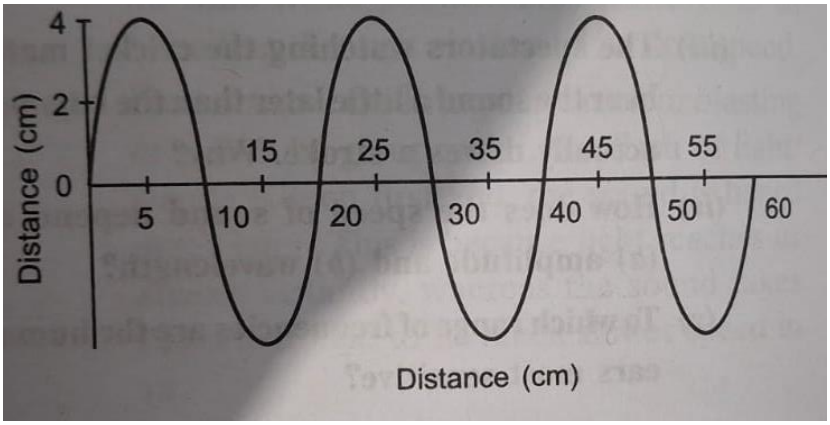
Ans. Wavelength $\lambda = 16$ cm

$= 0.16$ m.

Frequency $\nu = V / \lambda$

$= 12.0 / 0.16 = 75$ Hz.

71. The given figure shows a snapshot of a wave form of frequency 50 Hz in a string. The number on the figure represents distance in centimetres. Find (i) wavelength, (ii) the amplitude, and (iii) the velocity for the given wave motion.



Sol.

(i) Since one complete wave fits in 20 cm distance, hence the wavelength is 20 cm or 0.2 m
(ii) Amplitude of the wave = maximum displacement on either side of its mean position = 4 cm.
(iii) Wave velocity, $V = v\lambda = 50\ Hz \times 0.2\ m = 10\ m/s$.

72. On the sea shore, an observer observes that in one minute 72 waves reach the shore. Calculate their velocity if the wavelength of the waves is 5 m.

Sol.

Given: $\lambda = 5\ m$, $v = 72 / 60\ s^{-1}$, $V = ?$
$\therefore V = v\lambda = (72 / 60\ s) \times 5\ m = 6\ m/s$

73. The frequency of radio transmission station is 300 kHz. What is the wavelength of the radio waves? The speed of light in air, $c = 3.00 \times 10^8$ m/s.

Sol.

Given:
$v = 300\ kHz = 300 \times 10^3\ Hz$,
$c = 3.00 \times 10^8\ m/s$
, $\lambda = ?$
We know that $c = v\lambda$
$\lambda = c / v$
$= (3.00 \times 10^8\ m/s) / (300 \times 10^3\ Hz)$
$= 1000\ m$

74. A wave has a speed of 240 m/s and a wavelength of 3.2 m. What are the (i) frequency and (ii) period of the wave?

Sol.

Given:
V = 240 m/s,
λ = 3.2 m, v = ?, T = ?
V = vλ
(i) ⇒ v = V / λ = (240 m/s) / (3.2 m) = 75 Hz
(ii) Time period, T = 1 / v = 1 / (75 Hz) = 0.013 s

75. In a pond ripples are sent and a floating object goes up and down 6 times in 15 s. The wave crests are 0.4 m apart. Calculate the wavelength, frequency and speed of the water waves.

Sol.

Wavelength, λ = distance between two consecutive crests = 0.4 m.
Time period of the water waves, T = 15 / 6 = 2.5 s
Hence frequency of the water wave, v = 1 / (2.5 s) = 0.4 s^{-1}
Speed of the water waves, V = vλ
V = 0.4 s^{-1} × 0.4 m = 0.16 m/s

76. The distance between two consecutive troughs in a wave train produced in a string is 5 cm. Find the speed of the wave, if two complete waves pass through any point per second.

Sol.

Wavelength of the wave, λ = distance between two consecutive troughs = 5 cm
Frequency of the wave = 2 s^{-1}
∴ Speed of the wave, V = vλ = (2 s^{-1}) × 5 cm = 10 cm/s

77. Using SONAR, sound pulses are emitted at the surface of sea water which are detected after reflection from water bottom. If the time interval from the emission to the detection of the sound pulses is 2 seconds, find the depth of sea water, speed of sound in sea water 1531 m/s.

Sol.

Depth of sea water, d = (V × t) / 2
d = (1531 m/s × 2 s) / 2 = 1531 m

78. Wavelength of light waves (visible) range from 400 nm in the violet to about 700 nm in the red. What is the range of frequencies of light waves? The speed of electromagnetic waves in vacuum is

3×10^8 m/s.

Sol.

Given: c = 3×10^8 m/s, λ_v = 400 nm = 4×10^{-7} m, λ_r = 700 nm = 7×10^{-7} m, v_v = ?, v_r = ?
We know that c = vλ
$\Rightarrow v_v = c / \lambda_v = (3 \times 10^8 \text{ m/s}) / (4 \times 10^{-7} \text{ m}) = 7.5 \times 10^{14}$ Hz
$v_r = c / \lambda_r = (3 \times 10^8 \text{ m/s}) / (7 \times 10^{-7} \text{ m}) = 4.3 \times 10^{14}$ Hz

79. Calculate the corresponding wavelength range for the range of frequencies of (i) shortwave radio 1.5-300 MHz (ii) X-rays 5 nm to about 0.01 nm.

Sol.

Sol.
(i) Given:
c = 3×10^8 m/s,
v = 1.5 MHz = 1.5×10^6 Hz,
λ = ?
λ = c / v
= $(3 \times 10^8 \text{ m/s}) / (1.5 \times 10^6$ Hz)
= 200 m
For v = 300 MHz = 300×10^6 Hz, λ = $(3 \times 10^8 \text{ m/s}) / (300 \times 10^6 \text{ Hz}) = 1$ m
(ii) Wavelength of X-rays,
λ = 5 nm = 5×10^{-9} m
v = c / λ
= $(3 \times 10^8 \text{ m/s}) / (5 \times 10^{-9} \text{m})$
= 6×10^{16} Hz
For wavelength,
λ = 0.01 nm
= 0.01×10^{-9} m
= 10^{-11} m
v = $(3 \times 10^8 \text{ m/s}) / (10^{-11} \text{ m})$
= 3×10^{19} Hz.

80. Jinto seated 300 m from speaker. Alisha hears live broadcast 5000 km

away via satellite. Who hears music first and difference? (Vs = 343 m/s, c = 3×10^8 m/s):

Ans. Jinto's time

$t_j = 300 / 343 = 0.875$ s.

Alisha's time

$t_a = 5{,}000{,}000 / (3 \times 10^8)$

$= 0.017$ s.

Alisha hears it first.
Time difference = 0.875 - 0.017 = 0.858 s (~0.86 s).

81. Find the frequency of a sound wave such that its wavelength in water is the same as the wavelength in air at 20 °C of a sound wave of frequency 1000 Hz. Take speed of sound in water, V_w = 1480 m/s, speed of sound in air at 20 °C, V_a = 344 m/s.

Sol.

Given:
$V_a = 344$ m/s,
$v = 1000$ Hz,
$\lambda_a = ?$
$\lambda_a = V_a / v$
$= (344 \text{ m/s}) / (1000 \text{ Hz})$
$= 0.344$ m
According to question,
Wavelength of sound in water,
λ_w = Wavelength of sound in air
$\lambda_w = 0.344$ m;
$V_w = 1480$ m/s, $v_w = ?$
$v_w = V_w / \lambda_w$
$= (1480 \text{ m/s}) / (0.344 \text{ m}) = 4302.3$ Hz.

82. Find the wavelength for an (i) AM radio station with frequency 1000 kHz and (ii) FM radio station with frequency 100 MHz. Speed of radio waves in vacuum is equal to the speed of light. i.e. 3×10^8 m/s.

Sol.

Sol. (i) Given:

$v = 1000\ kHz = 10^6\ Hz$,
$c = 3 \times 10^8\ m/s$,
$\lambda = ?$
$\lambda = c / v$
$= (3 \times 10^8\ m/s) / (10^6\ Hz)$
$= 300\ m$
(ii) Given:
$c = 3 \times 10^8\ m/s$,
$v = 100\ MHz = 10^8\ Hz$,
$\lambda = ?$
$\lambda = (3 \times 10^8\ m/s) / (10^8\ Hz)$
$= 3\ m$

83. Ripples are generated by a vibrator on the surface of water which covers a distance of 37.8 cm in 1.8 s. The distance between consecutive crest and trough is 1.5 cm. Calculate the wavelength, wave velocity and the frequency of the generated waves.

Sol.

Wavelength of the generated wave, λ = twice the distance between consecutive crests and troughs = $2 \times 1.5\ cm = 3\ cm$.
Wave velocity (V) = 37.8 cm / 1.8 s = 21 cm/s
Frequency of the generated waves (v) = V / λ
$= (21\ cm/s) / (3\ cm) = 7\ s^{-1}$

84. A wave of periodic time 0.004 s travels with a speed of 4.8 km/s in iron. What will be its wavelength in (i) iron and (ii) air? Take speed of sound in air as 332 m/s.

Sol.

(i) Given:
$V_{iron} = 4.8\ km/s = 4800\ m/s$, $T = 0.004\ s$, $\lambda_{iron} = ?$
$\lambda_{iron} = V_{iron} \times T$
$= 4800\ m/s \times 0.004\ s$
$= 19.2\ m$
(ii) Given:
$V_{air} = 332\ m/s$, $T = 0.004\ s$, $\lambda_{air} = ?$
$\lambda_{air} = V_{air} \times T$
$= 332\ m/s \times 0.004\ s = 1.328\ m = 1.33\ m$

85. A stone is dropped into a well 44.1 m deep. The sound of the

splash is heard 3.13 s after the stone is dropped. Find the velocity of sound in air. Take g = 9.8 m/s².

Sol.

Let t_1 is the time for the downward motion (free fall) of stone to hit the water surface in the well and $t_2 = (3.13 - t_1)$ is the time for the sound of splash to reach the top of the well.

$h = u t_1 + (1/2) g t_1^2$

$-44.1 \text{ m} = 0 \times t_1 + (1/2) \times (-9.8 \text{ m/s}^2) \times t_1^2$

$t_1^2 = 44.1 / 4.9 = 9 \text{ s}^2$

$\Rightarrow t_1 = 3 \text{ s}$

$V = d / t_2$

$= 44.1 \text{ m} / (3.13 - 3) \text{ s}$

$= 44.1 \text{ m} / 0.13 \text{ s}$

$= 339.2 \text{ m/s}$

86. The sound of the splash of a stone dropped into a well is heard 3 s later. What is the depth of the well? Take speed of sound in air as 343 m/s.

Sol.

As the stone is dropped into the well, let it will take time t_1 for downward motion of the stone to hit the water surface in the well. Then the sound of splash reach the top of the well in time $t_2 = (3 - t_1)$

So using equation of motion

$s = u t_1 + (1/2) g t_1^2$

$u = 0, s = h,$

$h = (1/2) g t_1^2$

$\Rightarrow t_1 = \sqrt{(2h/g)}$

Now, the time taken by sound of splash to reach the top of the well

$t_2 = (3 - t_1) \text{ s} = 3 - \sqrt{(2h/g)}$

Velocity of sound (V) = depth of the well (h) / $t_2 = h / (3 - \sqrt{(2h/g)})$

$3 - \sqrt{(2h/g)} = h / V$

$\Rightarrow \sqrt{(2h/g)} = 3 - h / V$

Squaring both sides, we have

$2h / g = (3 - h / V)^2 = 9 + (h / V)^2 - 6h / V$

As $h << V$ so $(h / V)^2$ will be negligible, hence $(h / V)^2$ neglected.

$2h / g = 9 - 6h / V$

$\Rightarrow 2h / g + 6h / V = 9$

$\Rightarrow 2h (1/g + 3/V) = 9$

$\Rightarrow 2h (V + 3g) / (gV) = 9$

$h = 9\ g\ V / [2\ (V + 3g)] = (9 \times 9.8 \times 343) / [2 \times (343 + 3 \times 9.8)]$
$h = 30252.6 / 744.8 = 40.62$ m