General SCIENCE for Indian Railways RRB Exams

ALP/ Group D
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Covers Practice Exercises

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Chapter 1 Physical Quantities, Motion & Force

PHYSICAL QUANTITIES

Physics is the branch of science which deals with the study of matter, energy, and the interaction between them.

- A **scalar** is a physical quantity that has only a magnitude (size) E.g. : Distance, speed, time, power, energy, etc.
- A **vector** is a physical quantity that has both a magnitude and a direction. E.g. Velocity, displacement, acceleration, force etc.

Some physical quantities like moment of **inertia**, **stress**, etc. are neither scalar nor vector. They are **tensor**.

Seven Fundamental Physical Quantities and their Units

Physical Quantity	SI Unit	Symbol
Length	meter	*m*
Mass	kilogram	*Kg*
Time	second	*S*
Electric Current	ampere	*A*
Temperature	kelvin	*K*
Luminous intensity	candela	*Cd*
Amount of substance	mole	*mol*

Some Derived Physical Quantities and their Units

S. No.	Physical Quantity	cgs unit	SI unit	Relation
1.	Force	dyne	newton	1 newton = 10^5 dyne
2.	Work	erg	joule	1 joule = 10^7 erg

- An object is said to be at rest if it does not change its position with respect to its surroundings with the passage of time.
- A body is said to be in motion if its position changes continuously with respect to the surroundings (or with respect to an observer) with the passage of time.
- The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body moves.

Dispacement

- When a body moves from one position to another, the shortest (straight line) distance between the initial position and final position of the body, alongwith direction, is known as its displacement. The S.I. unit of displacement is metre (*m*). Displacement is a vector quantity.

Motion

- **Uniform motion :** A body has a **uniform motion** if it travels equal distances in equal intervals of time.
- **Non-uniform motion :** A body has a non-uniform motion if it travels unequal distances in equal intervals of time.

Speed : Distance travelled by a moving body in (one second) unit time is called speed. The S.I. units of speed is ms^{-1}.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

- The average distance covered by a body per unit time when the body is moving with non-uniform speed is known as **average speed.**

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

- **Velocity** of a body is defined as the displacement produced per unit time. It is the distance travelled by a body per unit time in a given direction. The S.I. unit of velocity is m/s.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Acceleration

- **Average Velocity :** It is defined as the total displacement covered divided by the total time taken.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

- **Acceleration :** It is defined as the rate of change of velocity with time.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}} \text{ or } a = \frac{v-u}{t}$$

The S.I. unit of acceleration is m/s^2.

Retardation: Negative acceleration is called 'retardation' or 'deceleration'.

- A body has uniform acceleration if it travels in a straight line and its velocity increases by equal amounts in equal intervals of time. For example, the motion of a freely falling body.
- A body has a non-uniform acceleration if the velocity increases by unequal amounts in equal intervals of time. In other words, a body has a non-uniform acceleration if its velocity changes at a non-uniform rate.
- **Equations of motion :** These are the equations which give relation between velocity, acceleration, distance covered, time taken for a body in uniform acceleration.

$$v = u + at$$

$$s = ut - \frac{1}{2}at^2$$

$$v^2 - u^2 = 2as$$

- In case the velocity of the object is changing at a uniform rate, then average velocity is given by the arithmetic mean of initial velocity and final velocity for a given period of time, i.e.,

$$\text{average velocity} = \frac{\text{initial velocity} + \text{final velocity}}{2}$$

Mathematically, $v_{av} = \frac{u + v}{2}$

when v_{av} is the average velocity, u is the initial velocity and v is the final velocity of the object.

- **Graphical Representation of Motion :**

(i) **Distance-time graph :** For uniform speed, a graph of distance travelled against time will be a straight line as shown by the line OA in figure given below.

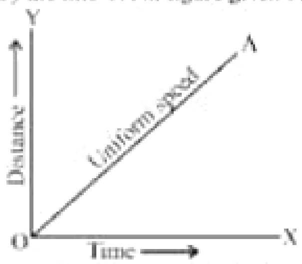


Fig. Distance-time graph for uniform speed

If the speed of a body is non-uniform, then the graph between distance travelled and time is a curved line.

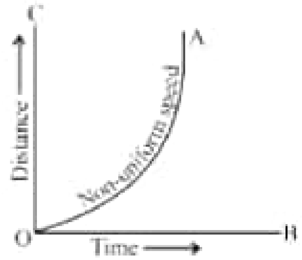


Fig. Distance-time graph for non-uniform speed

(ii) **Velocity-time graphs :**

(a) Velocity-time graph parallel to time axis (uniform motion)

(i) The area of the graph under velocity-time curve gives the displacement of the body.

Displacement = Velocity × Time

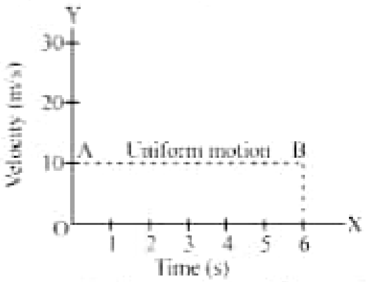


Fig. Velocity-time graph for uniform motion

(ii) The slope of velocity-time graph gives acceleration.

$$\text{Acceleration} = \frac{\text{Velocity}}{\text{Time}}$$

If the slope of graph is zero, the acceleration is zero.

(iii) If the slope of velocity-time graph is positive, then acceleration is a positive. If the slope is negative, then acceleration is negative i.e. retardation.

(b) Velocity-time graph is a straight line which is not parallel to time axis (uniform accelerated motion).

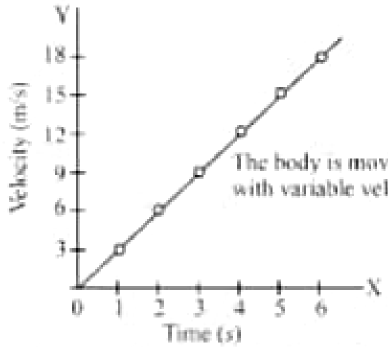


Fig. Graph between velocity and time (motion with uniform acceleration)

(c) The velocity-time graph is a curve for motion with a variable acceleration.

Projectile Motion

Projectile is the name given to a body thrown with some initial velocity in any arbitrary direction and then allowed to move under the influence of a constant acceleration. The motion of a projectile is called projectile motion.

Example : A football kicked by the player, a stone thrown from the top of building, a bomb released from a plane.

The path followed by a projectile is called its **trajectory**, mostly, the trajectory of a projectile is parabolic.

Maximum height (H): When a projectile moves, it covers a maximum distance in vertical direction. This maximum distance is called the maximum height attained by the projectile.

$$\text{Maximum height} \quad H = \frac{U^2 \sin^2 \alpha}{2g}$$

Horizontal range (R): The horizontal distance between the point of projection and the point of landing of a projectile.

$$\text{Maximum range} \quad R = \frac{U^2 \sin^2 2\alpha}{g}$$

Time of flight (T): The time taken by the projectile to reach the point of landing from the point of projection.

$$\text{Time of flight} \quad T = \frac{2u \sin^2 \alpha}{g}$$

Science in Action

- An aeroplane flying at a constant speed, if it releases a bomb, the bomb moves away from the aeroplane and it will be always vertical below the aeroplane as the horizontal component of the velocity of the bomb will be same as that of the velocity of the aeroplane. And thus the horizontal displacement remain same at any instant of time.
- If two bullets are fired horizontally, simultaneously and with different velocities from the same place, both the bullets will hit the ground simultaneously as the initial velocity in the vertically downward direction is zero and same height has to be covered.

FORCE

- Force may be defined as a push or a pull which changes or tends to change the state of rest or uniform motion or direction of motion of a body. SI units is Newton.
  A force can do three things on a body.
  (a) It can change the speed of a body.
  (b) It can change the direction of motion of a body.
  (c) It can change the shape of the body.
- **Newton's First Law of Motion :** If a body is in a state of rest, it will remain in the state of rest and if it in the state of motion, it will remain moving in the same direction with the same velocity unless an external force is applied on it. Its S.I. unit is kg.
  A body with greater mass has greater inertia.
- The momentum of a moving body is defined as the product of its mass and velocity momentum is a vector quantity given by

$$\vec{p} = m\vec{v}$$

The SI unit of momentum is kilogram meter per second (kgm/s).
- **Newton's Second Law of Motion :** It states the rate of change of momentum of a body is directly proportional to the applied unbalanced force.
  Rate of change in momentum $\propto$ Force applied.
- **Newton's Third Law of Motion :** According to this law, to every action, there is an equal and opposite reaction.
  When one object exerts a force (*action*) on another object, then the second object also exerts a force (*reaction*) on the first. These two forces are always equal in magnitude but opposite in direction.

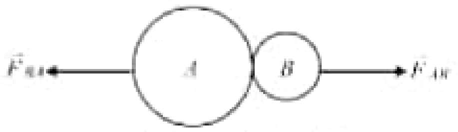
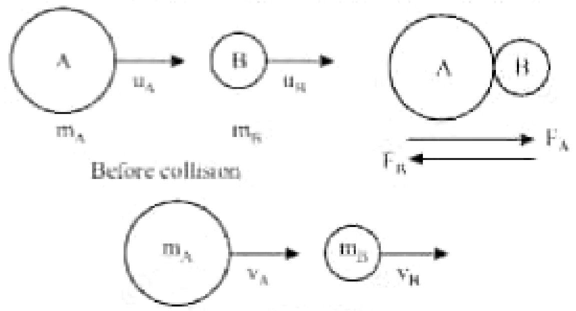


Fig. Newton's third law

- **Conservation of Momentum :** If the external force on a system is zero, the momentum of the system remains constant i.e. In an isolated system, the total momentum remains conserved.

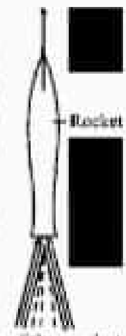


After collision

A and B are two balls, the mass and initial velocities are shown, before collision. The two bodies collide and force is exerted by each body. There is change in their velocities due to collision. $(m_Au_A + m_Bu_B)$ is the total momentum of the two balls A and B before collision and $m_Av_A + m_Bv_B$ is their total momentum after the collision. The sum of momentum of the two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force acting on them. This is known as the law of conservation of momentum.

Science in Action

- **Recoiling of a gun:** Guns recoil when fired, because of the law of conservation of momentum. The positive momentum gained by the bullet is equal to negative recoil momentum of the gun and so the total momentum before and after the firing of the gun is zero.
- **Propulsion of Jet and Rockets:** A rocket standing at the launching pad has zero momentum. When the propellants inside the rocket burn, a high velocity blast of hot gases is produced.



Theses gases pass out through the tail nozzle of the rocket in downward direction with tremendous velocity. Therefore the rocket moves up with such a velocity so as to make the momentum of the system (rocket + emitted gases) zero.

Circular Motion

- Motion of a body along a circular path is called circular motion.
- **Centripetal force** - while a body is moving along a circular path an external force required to act radially inward.
  A pseudo force that is equal and opposite to the centripetal force is called **centrifugal force**.
  Cream separator, centrifugal dryer, etc, work on the principle of centrifugal force.

Friction

Friction is a force that is created whenever two surfaces move or try to move across each other.
Friction always opposes the motion or attempted motion of one surface across another surface.
Instances where friction is important Walking , Driving ,Picking something up, Car brakes.

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Exercise

DIRECTIONS : This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which only one is correct.

1. If a body is moving at constant speed in a circular path, its
   (a) velocity is constant and its acceleration is zero
   (b) velocity and acceleration are both changing direction only
   (c) velocity and acceleration are both increasing
   (d) velocity is constant and acceleration is changing direction
2. A graph is plotted showing the velocity of a car as a function of time. If the graph is a straight line, it means that
   (a) the car started at rest
   (b) acceleration was constant
   (c) acceleration was increasing
   (d) velocity was constant
3. If a car is traveling north on a straight road and its brakes are applied, it will
   (a) have no acceleration
   (b) accelerate to the south
   (c) accelerate to the north
   (d) accelerate either east or west
4. An object moves with a uniform velocity when
   (a) the forces acting on the object are balanced
   (b) there is no external force on it
   (c) Both of (a) and (b)
   (d) Either (a) or (b)
5. The acceleration of a car that speeds up from 12 meters per second to 30 meters per second in 15 seconds–
   (a) 2.4 m/s^2 (b) 1.2 m/s^2
   (c) 2 m/s^2 (d) 5.2 m/s^2
6. A particle experiences constant acceleration for 20 seconds after starting from rest. If it travels a distance s_1 in the first 10 seconds and distance s_2 in the next 10 seconds, then
   (a) $s_2 = s_1$ (b) $s_2 = 2s_1$
   (c) $s_2 = 3s_1$ (d) $s_2 = 4s_1$
7. Friction forces act
   (a) in the direction of force applied
   (b) in the direction of the motion
   (c) in the direction opposite to the direction of motion
   (d) None of these
8. In which of the following cases, the object does not possess an acceleration or retardation when it moves in
   (a) upward direction with decreasing speed
   (b) downward direction with increasing speed
   (c) with constant speed along circular path
   (d) with constant speed along horizontal direction
9. By applying a force of one Newton, one can hold a body of mass
   (a) 102 grams (b) 102 kg
   (c) 102 mg (d) None of these
10. The speed of a falling body increases continuously, this is because
    (a) no force acts on it
    (b) it is very light
    (c) the air exert the frictional force
    (d) the earth attract it
11. The effect of frictional force may be minimized by
    (a) using a smooth object
    (b) using a smooth plane
    (c) providing a lubricant at the surface of contact
    (d) All of these
12. If an object is in a state of equilibrium
    (a) it is at rest
    (b) it is in motion at constant velocity
    (c) it is in free fall
    (d) may be more than one of the above
13. If a boat is moving along at constant speed, it may be assumed that
    (a) a net force is pushing it forward
    (b) the sum of only vertical forces is zero
    (c) the buoyant force is greater than gravity
    (d) the sum of all forces is zero
14. When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side because
    (a) we tend to continue in our straight line motion
    (b) an unbalanced force is applied by the engine of the motorcar changes the direction of motion of the motorcar
    (c) we slip to one side of the seat due to the inertia of our body
    (d) All of these
15. When a bus suddenly starts, the standing passengers lean backwards in the bus. It is an example of
    (a) Newton's first law
    (b) Newton's second law
    (c) Newton's third law
    (d) None of Newton's law
16. Momentum has the same units as that of
    (a) couple (b) torque
    (c) impulse (d) force
17. When a force of newton acts on a mass of 1 kg that is free to move, the object moves with a
    (a) speed of 1 m/s
    (b) speed of 1 km/s
    (c) acceleration of 10 m/s^2
    (d) acceleration of 1m/s^2
18. If an object experience a net zero unbalanced force, then the body
    (a) can be accelerated
    (b) moves with constant velocity
    (c) cannot remain at rest
    (d) None of these
19. A hockey player pushes the ball on the ground. It comes to rest after travelling certain distance because
    (a) the player stops pushing the ball
    (b) no unbalanced force action on the wall
    (c) the ball moves only when pushes
    (d) the opposing force acts on the body.
20. The physical quantity which is the product of mass and velocity of a body is known as
    (a) inertia (b) momentum
    (c) force (d) change in momentum
21. Rate of change of momentum of an object is proportional to the
    (a) balanced force applied
    (b) applied unbalanced force in the direction of the force
    (c) time during which the force is applied
    (d) All of these

22. A book of weight 10 N is placed on a table. The force exerted by the surface of the table on the book will be
(a) Zero (b) 10 N
(c) 20 N (d) None of these
23. A moving object can come to rest only if it
(a) has a frictional force acting on it
(b) has no net force acting on it
(c) is completely isolated
(d) applies an impulse to something else
24. When a body is stationary-
(a) There is no force acting on it
(b) The force acting on it not in contact with it
(c) The combination of forces acting on it balances each other
(d) The body is in vacuum
25. A rider on horse falls back when horse starts running, all of a sudden because
(a) rider is taken back
(b) rider is suddenly afraid of falling
(c) inertia of rest keeps the upper part of body at rest while lower part of the body moves forward with the horse
(d) None of the above
26. A man getting down a running bus, falls forward because
(a) due to inertia of rest, road is left behind and man reaches forward
(b) due to inertia of motion upper part of body continues to be in motion in forward direction while feet come to rest as soon as they touch the road
(c) he leans forward as a matter of habit
(d) of the combined effect of all the three factors stated in (a), (b) and (c)
27. A force 10 N acts on a body of mass 20 kg for 10 sec. Change in its momentum is
(a) 5 kg m/s (b) 100 kg m/s
(c) 200 kg m/s (d) 1000 kg m/s
28. Swimming is possible on account of
(a) first law of motion
(b) second law of motion
(c) third law of motion
(d) newton's law of gravitation
29. A man is at rest in the middle of a pond on perfectly smooth ice. He can get himself to the shore by making use of Newton's
(a) first law (b) second law
(c) third law (d) all the laws
30. A parrot is sitting on the floor of a closed glass cage which is in a boy's hand. If the parrot starts flying with a constant speed, the boy will feel the weight of the cage as
(a) unchanged (b) reduced
(c) increased (d) nothing can be said
31. A cannon after firing recoils due to-
(a) conservation of energy
(b) backward thrust of gases produced
(c) Newton's third law of motion
(d) Newton's first law of motion
32. Newton's third law of motion leads to the law of conservation of-
(a) angular momentum (b) energy
(c) mass (d) momentum
33. The force of friction acting on a car on different roads in the increasing order of magnitude will be
(a) mud, tar, concrete and gravel roads
(b) tar, concrete, gravel and mud roads
(c) concrete, tar, gravel and mud roads
(d) gravel, mud, tar and concrete roads
34. A fish is swimming upward at an angle of 30° with the horizontal. The direction of the force of gravity acting on it is-
(a) upward (b) downward
(c) horizontal (d) at an angle upward
35. Two blocks of mass 4 kg and 6 kg are placed in contact with each other on a frictionless horizontal surface. A push of 5N is applied on a heavier mass. The force on the lighter mass will be
(a) 3 N (b) 2 N
(c) 5 N (d) 50 N
36. Rockets work on the principle of conservation of
(a) energy (b) mass
(c) momentum (d) All of these
37. Motion of an object is the change in position with respect to a reference point known as
(a) origin (b) initial position
(c) final position (d) distance
38. Displacement is the
(a) shortest distance between initial and final positions
(b) the actual distance between initial and final positions
(c) the distance traveled by the object
(d) distance traveled by the object in a unit time
39. An object has traveled 10 km in 15 minutes, its displacement will be
(a) 10 km (b) Can be zero
(c) More than 10 km (d) All of the above
40. If an object covers equal distances in equal intervals of time, it is said to be in
(a) Circular Motion (b) Uniform Motion
(c) Oscillatory Motion (d) Non-uniform Motion
41. Average velocity of an object is obtained by
(a) Dividing the total distance traveled by the total time taken
(b) Half of the sum of the initial velocity and the final velocity
(c) Both (a) and (b)
(d) None of the above
42. Negative value of acceleration signifies
(a) The velocity is increasing
(b) The velocity is decreasing
(c) The velocity remains the same
(d) The object comes to rest
43. In distance-time graphs
(a) Distance is taken along the X- axis
(b) Time is taken along the Y-axis
(c) Straight line indicates uniform motion
(d) Straight line indicates non-uniform motion
44. In velocity-time graphs
(a) Velocity is taken along the Y-axis and Time is taken along the X-axis
(b) Straight line indicates uniform acceleration
(c) Straight line parallel to x-axis indicates uniform motion
(d) All of the above
45. The equation(s) of motion can be represented as
(a) $v = u + at$ (b) $s = ut + \frac{1}{2}at^2$
(c) $2as = v^2 - u^2$ (d) All of these

46. A train travels 40 km at a uniform speed of 30 km h^{-1}. Its average speed after traveling another 40 km is 45 km h^{-1} for the whole journey. Its speed in the second half of the journey is

(a) 45 km h^{-1} (b) 90 km h^{-1}
(c) 60 km h^{-1} (d) None of these

47. A man walks on a straight road from his home to market 2.5km. away with a speed of 5 km/h. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km/h. The average speed of the man over the interval of time 0 to 40 min. is equal to –

(a) 5 km/h (b) 25/4 km/h
(c) 30/4 km/h (d) 45/8 km/h

48. A person is standing in an elevator. In which situation he finds his weight less than actual when –

(a) The elevator moves upward with constant acceleration.
(b) The elevator moves downward with constant acceleration
(c) The elevator moves upward with uniform velocity
(d) The elevator moves downward with uniform velocity

49. A ball is dropped from a window 24 meters high. How long will it take to reach the ground ?

(a) 2.2 s (b) 1.2 s
(c) 4.5 s (d) 0.2 s

50. A pitcher throws his fastball horizontally at 42.1 meters per second.
How far does it drop before crossing the plate, 18.3 meters away?

(a) 0.8 m (b) 1.2 m
(c) 2.2 m (d) 0.93 m

51. Mohan takes 20 minutes to cover a distance of 3.2 kilometers due north on a bicycle, his velocity in kilometer/hour–

(a) 8.1 (b) 9.6
(c) 1.2 (d) 7.2

52. Two balls A and B of same masses are thrown from the top of the building. A, thrown upward with velocity V and B, thrown downward with velocity V, then –

(a) Velocity of A is more than B at the ground
(b) Velocity of B is more than A at the ground
(c) Both A and B strike the ground with same velocity
(d) None of these

53. A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball in T/3 seconds –

(a) h/9 meters from the ground
(b) 7h/9 meters from the ground
(c) 8h/9 meters from the ground
(d) 17h/18 meters from the ground

54. When a bus suddenly takes a turn, the passengers are thrown outwards because of –

(a) inertia of motion (b) acceleration of motion
(c) speed of motion (d) Both (b) and (c)

55. A thief snatches a purse and runs due west, going 6.0 meters per second. A policeman, 15 meters to the east, sees the event and gives chase. If the officer is a good sprinter, going at 8.5 meters per second, how far does he have to run to catch the thief –

(a) 12 m (b) 51 m
(c) 61 m (d) 55 m

56. A car going at 24 meters per second passes a motorcycle at rest. As it passes, the motorcycle starts up, accelerating at 3.2 meters per second squared. If the motorcycle can keep up that acceleration, how long will it take for it to catch the car –

(a) 12 s (b) 14 s
(c) 20 s (d) 18 s

57. The initial velocity of a body is 15 m/s. If it is having an acceleration of 10 m/s^2, then the velocity of body after 10 seconds from start –

(a) 110 m/s (b) 105 m/s
(c) 120 m/s (d) 115 m/s

37. **(a)** Motion of an object is the change in position with respect to a reference point called origin.

38. **(a)** Displacement is the shortest distance between initial and final positions.

39. **(d)** An object has traveled 10 km in 15 minutes, its displacement will be according to the direction it has followed.

40. **(b)** If an object covers equal distances in equal intervals of time, it is said to be in uniform motion.

41. **(b)** Average velocity of an object is obtained by taking the arithmetic mean of the initial and final velocity.

42. **(b)** Negative value of acceleration signifies deceleration or in other words the velocity is decreasing.

43. **(c)** In distance-time graphs, the distance is taken along the Y- axis, Time is taken along the X-axis. Straight line indicates uniform motion.

44. **(d)** In velocity-time graphs, Velocity is taken along the Y-axis and Time is taken along the X-axis. A straight line indicates uniform acceleration and a straight line parallel to X-axis indicates uniform motion.

45. **(b)** The equations of motion are

(1) $v = u + at$

(2) $s = ut + \frac{1}{2}at^2$

(3) $2as = v^2 - u^2$

46. **(b)** Let speed of the train in later half = x, then the time taken to travel later 40 km = 40/x hours

Total time taken = 40/30 + 40/x

$$\text{Average speed} = \frac{80}{4/3 + 40/x} = 45$$

Solve the equation to find value of x

47. **(d)** A man walks from his home to market with a speed of 5 km/h. Distance = 2.5 km and time = $\frac{d}{v} = \frac{2.5}{5} = \frac{1}{2}$ hr.

and he returns back with speed of 7.5 km/h in rest of time of 10 minutes.

$$\text{Distance} = 7.5 \times \frac{10}{60} = 1.25 \text{ km}$$

So, Average speed

$$= \frac{\text{Total distance}}{\text{Total time}} = \frac{(2.5 + 1.25)\text{ km}}{(40/60)\text{ hr}} = \frac{45}{8}\text{ km/h}$$

48. **(b)** The elevator moves downward with constant acceleration.

49. **(a)** In free fall, the acceleration is 9.8 m/s^2, there is uniform acceleration starting from rest, so $s = \frac{1}{2}at^2$

and $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 24\text{m}}{9.8\text{ m/s}^2}} = 2.2$ s

50. **(d)** The time it takes the ball to get to the plate, at constant horizontal speed, is (18.3 m)/42.1 m/s) = 0.435 s

During that time, gravity makes it drop a distance of

$$s = \frac{1}{2}at^2 = \frac{1}{2}(9.8\text{ m/s}^2)(0.435\text{ s})^2 = 0.93\text{ m}$$

51. **(b)** The total distance moved $s = 3.2$ km (due north)

The total time taken $t = 20$ minutes

$$= \frac{20}{60}\text{ hours} = \frac{1}{3}\text{ hours}$$

The velocity of the bicycle

$$v = \frac{\text{Total distance covered}}{\text{Total time taken}} = \frac{s}{t}$$

$$v = \frac{3.2\text{ km}}{(1/3)\text{ h}} = 9.6\text{ km/h due north}$$

52. **(c)** $v^2 = u^2 + 2gh \Rightarrow v = \sqrt{u^2 + 2gh}$

So, for both the cases velocity will be equal.

53. **(c)** $\because h = ut + \frac{1}{2}gt^2 \Rightarrow h = 0 + \frac{1}{2}gT^2$

After 1/3 seconds, the position of ball,

$$h' = 0 + \frac{1}{2}g\left(\frac{T}{3}\right)^2 = \frac{1}{2} \times \frac{g}{9} \times T^2$$

$$h' = \frac{1}{2} \times \frac{g}{9} \times T^2 = \frac{h}{9}\text{ m from top}$$

$\therefore$ Position of ball from ground $= h - \frac{h}{9} = \frac{8h}{9}$ m

54. **(a)** When a bus suddenly takes a turn, the passengers are thrown outwards because of inertia of motion.

55. **(b)** The thief runs a distance s in time t at 6.0 m/s, the policeman runs (s + 15m) in the same time, going 8.5 m/s. For both, time is distance over speed, so

$$t = \frac{s}{6.0\text{ m/s}} = \frac{(s + 15\text{m})}{8.5\text{ m/s}}\text{ from which } s = 36\text{ m.}$$

The policeman runs 51m.

56. **(b)** Both vehicles travel the same distance. For the car, going at constant speed, the distance is vt, for the motorcycle, it is $\frac{1}{2}at^2$

Then

$$s = (22\text{ m/s})\,t = \frac{1}{2}(3.2\text{ m/s}^2)\,t^2$$

from which $t = 14$s.

57. **(d)** The initial velocity of a body u = 15 m/s.

Acceleration of body a = 10 m/s^2

and time t = 10s

If v is the velocity of body after 10s then from equation

$v = u + at$

We have $v = 15 + 10(10) = 15 + 100 = 115$ m/s

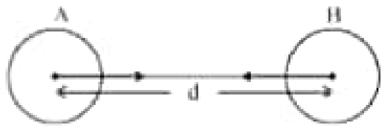
Chapter 2 Gravitation and Properties of Matter

GRAVITATION

- Gravitation is a natural phenomenon by which all physical bodies attract each other.
- On earth, gravity gives weight to physical objects employing a downward force to keep them grounded.
- It is weakest force among the four natural forces in nature, i.e. electromagnetic weak & strong nuclear force.

Universal Law of Gravitation

- Every object in the universe attracts every other object with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them. The force is along the line joining the centres of two objects.



Let two objects A and B of masses M and m lie at a distance d from each other as shown in figure given above. Let the force of attraction between two objects be F. According to the universal law of gravitation, the force between two objects is directly proportional to the product of their masses. That is,

$$F \propto M \times m \quad \text{...(1)}$$

And the force between two objects is inversely proportional to the square of the distance between them, that is,

$$F \propto \frac{1}{d^2} \quad \text{...(2)}$$

Combining equations (1) and (2), we get

$$F \propto \frac{M \times m}{d^2} \quad \text{...(3)}$$

or, $$F = G\frac{M \times m}{d^2} \quad \text{...(4)}$$

where G is the constant of proportionality and is called the universal gravitation constant. The S.I. unit of G can be obtained by substituting the units of force, distance and mass in Eq. (4) as $N m^2 kg^{-2}$.

The accepted value of G is 6.673×10^{-11} N m^2 kg^{-2}.

- When an objects fall down forwards the earth under the gravitational force alone, we say the object are in free-fall. The velocity of a freely falling body changes and is said to be accelerated. This acceleration is called acceleration due to gravity, denoted by 'g'. Unit is m/s^2.

As $F = ma$ $\quad (\because a = g)$ ...(i)

$F = mg$ ...(ii)

and $F = G = \frac{Mm}{d^2}$ (iii) Universal law of Gravitation

$\therefore$ $mg = G = \frac{Mm}{d^2}$ from (ii) and (iii)

$\therefore$ $g = \frac{GM}{d^2}$

M = Mass of the earth.

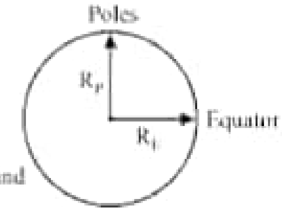
d = distance between the object and the earth.

G = Gravitational constant.

If the object is placed on the earth then $d = R$.

(R = radius of the earth)

$g = \frac{GM}{R^2}$



- Earth is not a sphere.

  It is flattened at poles.

  Hence R_p – Radius at pole and

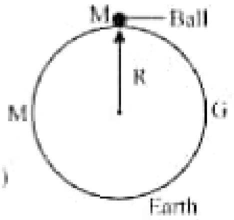
  R_e – Radius at equator.

  $R_e > R_p$

  $g \propto \frac{1}{R}$

  $\therefore$ The value of 'g' is more at Poles = (9.9 m/s^2) and less at equator = (9.8 m/s^2)

- Calcualte value of g



$g = G\frac{M}{R^2}$

$G = 6.67 \times 10^{-11}$ Nm^2/kg^2

$M = 6 \times 10^{24}$ kg. (Mass of the Earth)

$R = 6.4 \times 10^6$ m

On substituting the given values.

$$g = \frac{6.7 \times 10^{-11} Nm^2kg^2 \times 6 \times 10^{24} kg}{(6.4 \times 10^6 m)^2}$$

g = 9.8 m/s^2.

Mass

- The quantity of matter in a body is called mass. The SI unit of mass is kilogram (kg). Mass is usually denoted by 'm'.

Characteristics of mass

(i) Mass is a scalar quantity.

(ii) The mass of a body remains the same at all places. This means, the mass of a body on the earth, on the moon, or anywhere in the outer space remains the same.

(iii) The mass of a body can be measured with the help of a two-pan balance.

Weight

- The weight of a body on the earth is equal to the force with which the body is attracted towards the earth. Thus, the weight of a body on the earth is equal to the force of gravity exerted by the earth on that body. We know that

  Force of gravity acting on a body

  = Mass of the body × Acceleration due to gravity

  The force of gravity acting on a body by definition is equal to the weight of that body. So

  Weight of the body = Mass of the body × Acceleration due to gravity

  $W = m \times g = mg$

Weight of a body in a lift

(i) If lift is stationary or moving with uniform speed (either upward or downward), the apparent weight of a body is equal to its true weight.

(ii) If lift is going up with acceleration, the apparent weight of a body is more than the true weight.

(iii) If lift is going down with acceleration, the apparent weight of a body is less than the true weight.

(iv) If the cord of the lift is broken, it falls freely. In this situation the weight of a body in the lift becomes **zero**. This is the situation of weightlessness.

(v) While going down, if the acceleration of lift is more than acceleration due to gravity, a body in the lift goes in contact of the ceiling of lift.

Escape speed (ve) is the minimum speed with which an object just crosses the earth's gravitational field and never comes back.

$$V_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

- The escape velocity of Earth is about 11.2 kilometres per second and on moon it is 2.4 km/sec
- It is times the orbital velocity i.e. $V_e = \sqrt{2}V_o$

  The weight of an object can change from one place to the other, from one planet to the other.

- **Weight of an Object on the Moon:** Let the mass of an object be m. Let its weight on the moon be W_m. Let the mass of the moon be M_m and its radius be R_m.

  By applying the universal law of gravitation, the weight of the object on the moon will be

$$W_m = G\frac{M_m \times m}{R_m^2} \quad ...(1)$$

Let the weight of the same object on the earth be W_e. The mass of the earth is M and its radius is R.

Celestial body	Mass (kg)	Radius (*m*)
Earth	5.98×10^{24}	6.37×10^{6}
Moon	7.36×10^{22}	1.74×10^{6}

From eq. (1) we have,

$$W_e = G\frac{M \times m}{R^2} \quad (2)$$

Substituting the values from table in eqs. (1) and (2), we get

$$W_m = G\frac{7.36 \times 10^{22}\ \text{kg} \times m}{(1.74 \times 10^6\ m)}$$

$W_m = 2.431 \times 10^{10}\, G \times m$ ...(3a)

and $W_e = 1.474 \times 10^{11}\, G \times m$ ...(3b)

Dividing eq. (3a) by eq. (3b), we get

$$\frac{W_m}{W_e} = \frac{2.431 \times 10^{10}}{1.474 \times 10^{11}}$$

$$\text{or} \quad \frac{W_m}{W_e} = 0.165 \approx \frac{1}{6} \quad ...(4)$$

$$\frac{\text{Weight of the object on the moon}}{\text{Weight of the object on the earth}} = \frac{1}{6}$$

Weight of the object on the moon = $\frac{1}{6}$ × its weight on the earth.

Satellite

It is a heavenly body or an artificial object which revolves round a planet in a particular orbit. The required centripetal force is provided by the gravitational force. Kepler's laws of planetary motion are applicable to them.

(a) **Orbital velocity of a satellite:** Velocity with which the satellite orbits around the planet.

$$v_o = \sqrt{\frac{GM}{R+h}}$$

(b) **Time period of a satellite:** Time taken by it to complete one revolution around the planet.

$$T = \frac{2\pi}{R}\sqrt{\frac{(R+h)^3}{g}}$$

(c) **Height of a satellite above the surface of the planet:**

$$H = \left(\frac{T^2R^2g}{4\pi^2}\right) - R$$

(d) **Total energy of a satellite** orbiting on a circular path is negative with potential energy being negative but twice as the magnitude of positive kinetic energy.

(e) **Binding energy** of a satellite is the energy required to remove it from its orbit to infinity.

B.E. = $\frac{GMm}{2r}$ No energy is required to keep the satellite in its orbit.

Geostationary satellites: The satellites in a circular orbit around the earth in the equatorial plane with a time period of 24 hours, appears to be fixed from any point on earth are called geostationary satellite.

- **Slow rise** in barometre reading is the indication of **clear weather**.
- Atmospheric pressure decreases with height or altitude. This is why- fountain pen leaks in aeroplane at height, cooking on the mountain is difficult, etc.

Buoyancy and Archimedes Principle

If a body is partially or wholly immersed in a fluid, it experiences an upward force due to the fluid surrounding it. This phenomenon of force exerted by fluid on the body is called **buoyancy** and force is called **buoyant force** or **upthrust**.

Archimedes' Principle: *It states that the buoyant force on a body that is partially or totally immersed in a fluid is equal to the weight of the fluid displaced by it.*

Bernoulli's Principle

When incompressible, non-viscous, irrotational liquid i.e., ideal liquid flow from one position to other in streamline path then in its path at every point, the sum of pressure energy, kinetic energy and potential energy per unit volume remains constant. Blowing of roofs by storms, sprayer action of carburetor, etc. are based on Bernoulli's principle.

Viscosity

The property of a fluid due to which it opposes the relative motion between its different layers is called viscosity (or fluid friction or internal friction) and the force between the layers opposing the relative motion is called **viscous force**.

Terminal Velocity

It is maximum constant velocity acquired by the body while falling freely in a viscous medium.

Surface Tension

The liquid surface behaves like a stretched elastic membrane which has a natural tendency to contract and tends to have a minimum possible surface area. This property of liquid is called surface tension.

$$\text{Surface tension } T = \frac{\text{Force } F}{\text{Length } L}$$

Examples of surface tension

(i) Raindrops are spherical in shape.

(ii) The hair of a shaving brush cling together when taken out of water.

(iii) Oil spread on cold water but remains as a drop on hot water etc.

Surface tension of a liquid decreases with temperature and becomes zero at critical temperature.

Capillarity

A glass tube with fine bore and open at both ends is known as capillary tube. *The property by virtue of which a liquid rise or fall in a capillary tube is known as* **capillarity**. Rise or fall of liquid in tubes of narrow bore (capillary tube) is called capillary action. Rise of kerosene in lanterns, rise of ink in fountain pen etc. are due to capillary action.

For geostationary satellite, height above the earth's surface = 35800 km and orbital velocity = 3.1 km/s.

Polar Satellites: A satellite that revolves in a polar orbit along north-south direction while the earth rotates around its axis in east west direction.

Weightlessness: A situation where the effective weight of the object becomes zero. An astronaut experiences weightlessness in space satellite because the astronaut as well as the satellite are in a free fall state towards the earth.

PROPERTIES OF MATTER

Elasticity and Plasticity

The property of the body to regain its original configuration (length, or shape) when the deforming forces are removed is called ***elasticity***. Quartz and phosphorous bronze, are closed to perfectly lastic body. On the other hand, *if the body does not have any tendency to regain its original configuration on removal of deforming force the body is called plastic body and this property is called* ***plasticity***.

Putty and mud are close to perfectly plastic body.

Stress: *The internal restoring force acting per unit area of a body is called stress.*

i.e., *Stress = Restoring force/ Area*

Strain: The ratio of change in configuration to the original configuration is called strain.

$$i.e.,\ Strain = \frac{Change\ in\ configuration}{Original\ configuration}$$

Strain being the ratio of two like quantities has **no units** and **dimensions**.

Elastic Limit

Elastic limit is the upper limit of deforming force up to which, if deforming force is removed, the body regains its original form completely and beyond which, if deforming force is increased, the body loses its property of elasticity and gets permanently deformed.

Hooke's law

It states that *within the elastic limit stress is directly proportional to strain.*

i.e., $Stress \propto strain$

or $Stress = E \times strain$

Here E is the coefficient of proportionality and is called **modulus of elasticity** or **coefficient of elasticity** of a body.

Young's modulus of elasticity (Y): It is defined as *the ratio of normal stress to the longitudinal strain within the elastic limit.*

$$\text{Thus, } Y = \frac{Normal\ stress}{Longitudinal\ strain}$$

Materials-Ductile, Brittle and Elastomers

(i) **Ductile materials:** *The materials which have large range of plastic extension* are called ductile materials. They can be drawn into thin wires, e.g., copper, silver, aluminium, iron, etc.

(ii) **Brittle materials:** *The materials which have very small range of plastic extension* are called brittle materials. These materials break as soon as stress is increased beyond the elastic limit. e.g., glass, ceramics, cast iron, etc.

(iii) **Elastomers:** *The materials which can be stretched to large values of strain* are called elastomers. *e.g.*, rubber, elastic tissue of aorta, etc.

Fluids

Fluids are the substances that can flow. Therefore liquids and gases both are fluids. The study of fluids at rest is called **fluid statics** or **hydrostatics** and the study of fluids in motion is called **fluid dynamics** or **hydrodynamics**. Both combined are called **fluid mechanics**.

Density (ρ)

Mass per unit volume is defined as density.

$$\rho = \lim_{\Delta v \to 0} \frac{\Delta m}{\Delta V} = \frac{dm}{dV} = \frac{m}{V}$$

Relative Density

It is defined as the ratio of the density of the given fluid to the density of pure water at 4°C. It is given by

$$= \frac{Density\ of\ given\ liquid}{Density\ of\ pure\ water\ at\ 4°C}$$

The density of water is maximum at 4°C and is equal to 1.0×10^3 kgm^{-3}

Relative density is measured by hydrometer.

Pressure

If a uniform force is exerted normal to an area (A), then *average pressure* (P_{av}) *is defined as the normal force (F) per unit area.*

$$i.e.,\ P_{av} = \frac{F}{A}$$

In limiting sense, *pressure*. The pressure exerted by liquid (density = ρ) at depth 'h' below the surface of liquid, $p = h\rho g$.

SI unit: pascal (Pa), 1 Pa = 1 N/m^2

Practical units: atmospheric pressure (atm), bar and torr

1 atm = 1.01325×10^5 Pa = 1.01325 bar = 760 torr = 760 mm of Hg column pressure.

Pascal's Law of Transmission of Fluid Pressure

Pascal's law is stated in following ways:

- The pressure in a fluid at rest is same at all the points if gravity is ignored.
- A liquid exerts equal pressures in all directions.
- If the pressure in an enclosed fluid is changed at a particular point, the change is transmitted to every point of the fluid and to the walls of the container without being diminished in magnitude.

Applications of Pascal's law: Hydraulic machines, lifts, presses and brakes, are based on the Pascal's law.

Atmospheric Pressure

Force exerted by air column on unit cross-section area of sea level is called atmospheric pressure (P_o)

$$P_0 = \frac{F}{A} = 101.3 kN/m^2$$

Barometer is used to measure atmospheric pressure which was **discovered by Torricelli.**

Atmospheric pressure varies from place to place and at a particular place from time to time.

Sudden fall in barometer reading is the indication of **storm**.

- **Slow fall** in barometre reading is the indication of **rain**.

10. The weight of an object
   (a) is the gravity of the matter it contains
   (b) refers to its inertia
   (c) is the same as its mass but expressed in different units
   (d) is the force with which it is attracted to the earth
11. In vacuum all freely falling objects
   (a) have the same speed
   (b) have the same velocity
   (c) have the same acceleration
   (d) have the same force
12. The centripetal force is provided to the planet by the
   (a) force of repulsion between the planet and the Sun
   (b) force of attraction of the Sun
   (c) heat energy of the Sun
   (d) All of these
13. At which of the following locations, the value of g is the largest?
   (a) On top of the Mount Everest
   (b) On top of Qutub Minar
   (c) At a place on the equator
   (d) A camp site in Antarctica
14. A ball is thrown vertically upwards. The acceleration due to gravity.
   (a) is in the direction opposite to the direction of its motion
   (b) is in the same direction as the direction of its motion
   (c) increases as it comes down
   (d) becomes zero at the highest point
15. Pressure exerted by a sharp needle on a surface is :
   (a) more than the pressure exerted by a blunt needle
   (b) less than the pressure exerted by a blunt needle
   (c) equal to the pressure exerted by a blunt needle
   (d) None of these
16. Which of the following is the force of attraction exists between objects ?
   (a) The inter molecular force of attraction
   (b) The force of buoyancy
   (c) The friction between planet and Sun
   (d) The force of attraction between objects is called the gravitational force.
17. Buoyant force on an object due to a fluid always acts:
   (a) in the downward direction
   (b) side ways
   (c) in the upper direction
   (d) None of these
18. A wooden cube floating in water supports a mass m = 0.2kg on its stop. When the mass is removed the cube rises by 2cm. The side of the cube is – (density of water $10^3 kg/m^3$)
   (a) 6 cm (b) 12 cm
   (c) 8 cm (d) 10 cm
19. Universal law of gravitation states that every object in the universe
   (a) Attracts every other object with a force
   (b) The force of attraction is proportional to the product of their masses
   (c) The force is inversely proportional to the square of the distance between them
   (d) All of these
20. Iron nail sinks in water because :
   (a) weight of nail is less than the buoyant force acting on it due to water
   (b) weight of nail is equal to the buoyant force acting on it due to water
   (c) weight of nail is greater than the buoyant force acting on it due to water
   (d) weight of nail increases in the water
21. When an object is made to float in two different liquids of density d_1 and d_2 , the lengths of the object seen above the liquid surface are l_1 and l_2 respectively. Which of the following is the correct alternative?
   (a) $d_2 > d_1$, if $l_1 > l_2$
   (b) $d_1 > d_2$, if $l_2 > l_1$
   (c) $d_1 < d_2$, if $l_2 > l_1$
   (d) $d_2 < d_1$, if $l_2 > l_1$
22. An object just foats in water. If common salt is added into the water
   (a) the volume of the object immersed in the liquid decreases
   (b) the object sinks
   (c) the object first sinks and then floats up
   (d) cannot be determined
23. Kepler's laws governing the motion of planets are:
   (a) The orbit of a planet is an eclipse with the Sun at one of the foci
   (b) The line joining the planet and the Sun sweep equal areas in equal intervals of time
   (c) The cube of the mean distance of a planet (r) from the Sun is proportional to the square of its orbital period (T)
   (d) All of these
24. A substance floats in water, but sinks in coconut oil. The density of the substance
   (a) is less than the density of water
   (b) is greater than the density of oil
   (c) Both (a) and (b)
   (d) Cannot be decided from the given information
25. A nurse applies a force of 3.8 N to the syringe's piston of radius 0.9 cm. Find the increase in pressure of the fluid in the syringe?
   (a) 14.927 kPa (b) 469.13 Pa
   (c) 46.9 mPa (d) 422 Pa
26. A rectangular tank of 6 m long, 2 m broad and 2 m deep is full of water, the thrust acting on the bottom of the tank is:
   (a) 23.52×10^4 N (b) 23.52 N
   (c) 11.76×10^4 N (d) 3.92×10^4 N
27. According to Kepler, force acting on an orbiting planet is given by
   (a) F = m g (b) F O < v^2 / r
   (c) F = m g h (d) None of these
28. Two stretched membranes of area 2 cm^2 and 3 cm^2 are placed in a liquid at the same depth. The ratio of the pressure on them is:
   (a) 1 : 1 (b) 2 : 3
   (c) 3 : 2 (d) $2^2 : 3^2$
29. Pick up the correct relationship
   (a) Gravitational constant $G = Fd^2 / M \times m$
   (b) $G = g M / R^2$
   (c) G = g (d) All of these
30. The gravitational force between two objects is F. If masses of both objects are halved without changing distance between them, then the gravitational force would become
   (a) F/4 (b) F/2
   (c) F (d) 2 F

31. A boy is whirling a stone tied with a string in an horizontal circular path the string breaks, the stone
    (a) will continue to move in the circular path
    (b) will move along a straight line towards the centre of the circular path
    (c) will move along a straight line tangential to the circular path
    (d) will move along a straight line perpendicular to the circular path away from the boy
32. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}, \frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?
    (a) $d_1 > d_2 > d_3$ (b) $d_1 > d_2 < d_3$
    (c) $d_1 < d_2 > d_3$ (d) $d_1 < d_2 < d_3$
33. S.I. Unit of G is
    (a) $m\ s^{-2}$ (b) $N\ m^2\ kg^{-2}$
    (c) No unit (d) None of these
34. Two particles are placed at some distance. If the mass of each of the two particles is doubled, keeping the distance between them unchanged, the value of gravitational force between them will be
    (a) $\frac{1}{4}$ times (b) 4 times
    (c) $\frac{1}{2}$ times (d) unchanged
35. The weight of an object at the centre of the earth of radius R is
    (a) zero
    (b) infinite
    (c) R times the weight at the surface of the earth
    (d) $1/R^2$ times the weight at surface of the earth
36. A girl stands on a box having 60 cm length, 40 cm breadth and 20 cm width in three ways. In which of the following cases, pressure exerted by the brick will be
    (a) maximum when length and breadth form the base
    (b) maximum when breadth and width form the base
    (c) maximum when width and length form the base
    (d) the same in all the above three cases
37. Value of G is
    (a) $9.8\ m\ s^{-2}$
    (b) $6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$
    (c) 6.673 N
    (d) 9.8 N
38. An apple falls from a tree because of gravitational attraction between the earth and apple. If F_1 is the magnitude of force exerted by the earth on the apple and F_2 is the magnitude of force exerted by apple on earth, then
    (a) F_1 is very much greater than F_2
    (b) F_2 is very much greater than F_1
    (c) F_1 is only a little greater than F_2
    (d) F_1 and F_2 are equal
39. If upthrust U is equal to $\frac{1}{4}$ th the weight of the object in air, then the weight felt in the liquid is
    (a) $\frac{1}{4}$ W (b) $\frac{3}{4}$ W
    (c) $\frac{1}{2}$ W (d) 2W
40. Gravitational force between the earth and an object on the surface of earth is best given by the formula
    (a) $F = m\,g$ (b) $F = g\,M / r^2$
    (c) $F = G \times M \times m / d^2$ (d) All of these
41. Four planets A, B, C and D made up of same material have radius of $\frac{r}{2}$, r, $2r$ and $4r$ respectively. The order of the planets in increasing order of the acceleration due to gravity (on their surface) is
    (a) A, B, C, D (b) B, C, D, A
    (c) A, C, B, D (d) D, C, B, A
42. Universal law of gravitation explains the phenomenon
    (a) The force that binds us to the earth
    (b) The motion of the moon around the earth or planets around the Sun
    (c) The tides due to the moon and the Sun
    (d) All of the these
43. The least value of apparent weight of a body in a fluid is
    (a) > 0
    (b) = 0
    (c) < 0
    (d) depends on the density of solid and fluid
44. A heavy cylinder of length l is slowly taken out of a dense liquid. The weight felt as it is taken out of the liquid.
    (a) will remain the same
    (b) increases as it comes out
    (c) decreases as it comes out
    (d) increases till it attains the weight in air
45. An empty closed drum and a filled drum of same dimension will bring
    (a) same upthrust (b) same volume
    (c) both (a) and (b) (d) neither (a) nor (b)
46. Acceleration due to gravity for objects on or near the surface of the earth is represented as
    (a) $g = G\,M / R^2$ (b) $g = G\,M\,m / d^2$
    (c) Both (a) and (b) (d) Neither (a) nor (b)
47. Upthrust varies as a body comes out of the liquid as
    A : It depends on immersed volume alone
    B : Volume = Cross-section area × Length
    Then
    (a) Only A is correct
    (b) Only B is correct
    (c) Both A and B are correct
    (d) Neither A nor B is correct
48. An earth-like planet has a radius equal to double the earth's radius. The acceleration due to gravity on its surface will be
    (a) g (b) $\frac{g}{2}$
    (c) $2g$ (d) g^2
49. The value of g becomes
    (a) greater at the poles than at the equator
    (b) greater at the equator than at the North Pole
    (c) greater at the equator than at the South Pole
    (d) zero at the equator

50. Four students A, B, C and D find the acceleration due to gravity at the top of Ooty, Nainital, Mount Everest and Shimla. The acceleration due to gravity is the least
    (a) at Ooty since it is the highest
    (b) at Mount Everest as it is the highest
    (c) at Nainital as only latitude has the effect and not height of the peak.
    (d) at Shimla as it is the coldest
51. Value of g is taken as
    (a) Positive for acceleration during free fall
    (b) Negative when the objects are thrown upwards
    (c) Positive in both cases
    (d) Only (a) and (b)
52. An object is thrown upwards and rises to the height of 10 m, which of the following is not correct.
    (a) Initial velocity = 14 ms^{-1}
    (b) Final velocity = 0 ms^{-1}
    (c) Time taken to reach the highest point = 1.43 s
    (d) Acceleration of the object = + 9.8 ms^{-2}
53. The weight of an object is the
    (a) Mass of the object
    (b) Force with which it is attracted towards the earth
    (c) Product of its mass and acceleration due to gravity
    (d) Only (b) and (c)
54. Weight on object weighting 10 kg on earth will become
    (a) $1/6^{th}$ on the moon (b) $W_m = G M m / R_m^2$
    (c) 98 N on moon (d) All of these
55. The force acting on an object perpendicular to the surface is called
    (a) buoyancy (b) thrust
    (c) surface Tension (d) None of these
56. Pressure is
    (a) Thrust per unit area (b) Measured in N m^{-2}
    (c) Measured in Pascal (d) All of these
57. Buoyant force is
    (a) the upward force exerted by a liquid on an object
    (b) known as up thrust
    (c) force exerted by an object on the liquid
    (d) Only (a) and (b)
58. Magnitude of the buoyant force depends on
    (a) mass of the object (b) mass of the fluid
    (c) density of the fluid (d) weight of the object
59. Select the correct statement :
    (a) Objects of density less than that of a liquid will float on the liquid.
    (b) Objects of density more than that of a liquid will sink in the liquid.
    (c) Both (a) and (b)
    (d) None of these
60. Archimedes principle states that :
    (a) When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.
    (b) When a body is floating on a liquid, it experiences a down ward force that is equal to the weight of the fluid under it
    (c) When a body is immersed in a fluid, it experiences an upward force that is equal to the difference in their weights
    (d) All are true
61. Relative density of a substance
    (a) is described as the ratio of the density of a substance to that of air
    (b) is described as the ratio of the density of a substance to that of water
    (c) does not have any unit
    (d) Both (b) and (c)

28. **(a)**

29. **(a)** Gravitational constant $G = Fd^2 / M \times m$

30. **(a)** **31.** **(c)** **32.** **(d)**

33. **(b)** S.I. Unit of G is $N\ m^2\ kg^{-2}$

34. **(b)** **35.** **(a)** **36.** **(b)**

37. **(b)** Value of $G = 6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$

38. **(d)** **39.** **(b)**

40. **(c)** Gravitational force between the earth and an object on the surface of earth is best given by the formula

$F = G \times M \times m / d^2$.

41. **(a)**

42. **(d)** Universal law of gravitation explains several unconnected phenomenon like the force that binds us to the earth, the motion of the moon around the earth or the planets around the Sun and also the formation of tides due to the moon and the Sun.

43. **(b)** **44.** **(d)** **45.** **(c)**

46. **(a)** Acceleration due to gravity for objects on or near the surface of the earth is represented as $g = G\ M / R^2$

47. **(c)** **48.** **(c)**

49. **(a)** The value of g becomes greater at the poles than at the equator, because is not a perfect sphere.

50. **(b)**

51. **(d)** Value of g is taken as positive for acceleration during free fall and negative, if the objects are thrown upwards.

52. **(d)** An object is thrown upwards it is moving against the gravitation. So, the acceleration of the object is taken as negative. Using the equations of motion, calculate the values of u, v, and t.

53. **(d)** The weight of an object is the force with which it is attracted towards the earth. $W = mg$

54. **(d)** Weight on object weighing 10 kg on earth will become 1/6[th] on the moon, i.e. 98 N. It is calculated by using the formula $W_m = G\ M\ m / R_m^2$

55. **(b)** The force acting on an object perpendicular to the surface is called thrust.

56. **(d)** Pressure is the thrust per unit area. Its S.I. Unit is Pascal or $N\ m^{-2}$

57. **(d)** The upward force exerted by a liquid on an object is known as up thrust or buoyant force.

58. **(c)** Magnitude of the buoyant force depends on the density of the fluid.

59. **(c)** Objects of density less than that of a liquid will float on the liquid and the objects of density more than that of a liquid will sink in the liquid.

60. **(a)** Archimedes principle states that: when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

61. **(d)** Relative density of a substance is described as the ratio of the density of a substance to that of water.

Chapter 3 Work, Energy and Power

WORK

- In physics work is defined if force applied on object displaces the object in direction of force. We define the work as : Product of the force and displacement in the direction of applied force or product of displacement and force in the direction of displacement.

  W = Force × displacement (force in direction of displacement)
- The SI unit of force is a newton and the unit of length is a metre (*m*). So the SI unit of work is newton-meter which is written as Nm. This unit (Nm) is also called joule (*J*), i.e.

  1 joule = 1 newton . 1 metre

  Abbreviated, this is 1 J = 1 Nm

  When a force of 1 newton moves a body through a distance of 1 metre in its own direction the work done is 1 Joule.
- If displacement is in the direction of the force

  W = F × S

  force
↑↑
Displacement
W = + ve

  When a horse pulls a cart, the applied force and the displacement are in the same direction. So, work done by the horse is positive.
- If displacement is in the direction opposite to the force.

  W = – F × S   (W = – ve) ↑ force ↓ displacement
- If displacement is perpendicular to the force work done is zero.

  force ↑ → displacement

Examples :

(i) A coolie with a luggage on his head, moving on a horizontal platform, does no work, since the direction of force is vertically up and displacement horizontal (even though he might feel physically tired).

(ii) If a boy tries to push a heavy boulder, by applying a force, but unable to displace it, then work done by the boy is zero.

- The energy may be defined as the capacity of a body to do work. The SI unit of energy is joule (*J*). Quite often, a bigger unit called kilo Joule (*kJ*) is used. Energy is a scalar quantity.

  1 kilo Joule = 1000 Joules

  or 1 kJ = 1000 J

ENERGY

- Energy is the capacity of doing work.
- It is a scalar quantity.
- The SI unit is joule (J) same as of work.

  Forms of energy : The various forms include potential energy, kinetic energy, heat energy, chemical energy, and light energy.
- Energy possessed by a body by virtue of its state of motion is called Kinetic energy. Kinetic energy is always positive and is a scalar. The fact, that moving bodies carry energy with them is proved by some of the several happenings in day to day life.

  Kinetic Energy, K = $\frac{1}{2}mv^2$, when m is the mass and v is the velocity of body.

Examples :

(i) A stone thrown with some velocity, breaks the window pane.

(ii) A moving vehicle, when accidently happens to collide with another vehicle at rest or motion, leads to destruction.

- Potential energy is energy due to position. If a body is in a position such that if it were released it would begin to move, it has potential energy. There are two common forms of potential energy, gravitational and elastic.

(i) Gravitational Potential Energy (GP_E) : When an object is raised through a height work is said to be done on it against gravity. The energy possessed by such an object is called the gravitational potential energy.

(ii) Elastic Potential energy : This is a kind of potential energy which is due to a change in the shape of a body. The change in shape of a body can be brought about by stretching, compressing, bending and twisting the body. Some work has to be done to change the shape of a body. This work gets stored in the deformed body in the form of elastic potential energy.

- **Law of Conservation of Energy :** According to this law, energy can only be converted from one form to another; it can neither be created or destroyed. The total energy before and after the transformation remains the same. The law of conservation of energy is valid in all situations and for all kinds of transformations.

Some Equipments used to Transform Energy is given below

S. No.	Equipment	Energy Transformed
1.	Dynamo	Mechanical energy into electrical energy
2.	Candle	Chemical energy into light and heat energy
3.	Microphone	Sound energy into electrical energy
4.	Loud Speaker	Electrical energy into sound energy
5.	Solar Cell	Solar energy into electrical energy
6.	Electric Bulb	Electrical energy into light and heat energy
7.	Battery	Chemical energy into electrical energy
8.	Electric motor	Electrical energy into mechanical energy

- Let an object of mass, m be made to fall freely from a height, *h*. At the start, the potential energy is *mgh* and kinetic energy is zero because its velocity is zero. The total energy of the object is thus mgh. As it falls, its potential energy will change into kinetic energy. If v is the velocity of the object at a given instant, the kinetic energy would be $\frac{1}{2}mv^2$. As the fall of the object continues, the potential energy would decrease while the kinetic energy would increase. When the object is about to reach the ground, h = 0 and v will be the highest. Therefore, the kinetic energy would be the largest and potential energy the least. However, the sum of the potential energy and kinetic energy of the object would be the same at all points. That is, potential energy + kinetic energy = constant

or $mgh + \frac{1}{2}mv^2 = \text{constant}$

The sum of kinetic energy and potential energy of an object is its total mechanical energy.

POWER

- The time rate of doing work is defined as power (*P*). If equal works are done in different times, power will be different. More quickly work is done, power will be more.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

- The unit of power is the joule per second and this is called the watt (*W*). When large amounts of power are involved, a more convenient unit is the kilowatt (kW) where 1 kW = 1000 W.

1 Megawatt = 10^6 watt

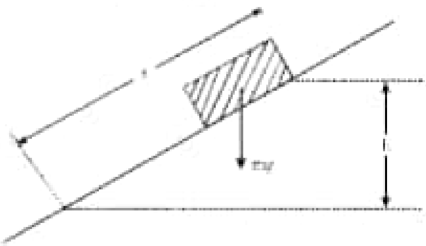
Power was also measured earlier in a unit called horse power. Even these days, the unit of horse power is in common use.

1 horse power = 746 watt

The unit kilowatt-hour means one kilowatt of power supplied for one hour. It is, therefore, the unit of energy.

1 KWh = (1000 J/s) × 60 × 60s = 3.6 × 10^6 J

9. If a force F is applied on a body and it moves with velocity v, the power will be –
   (a) F v (b) F/v
   (c) Fv^2 (d) F/v^2
10. The kinetic energy of a body becomes twice its initial value. The new momentum of the body will be
   (a) 2 times (b) $\sqrt{2}$ times
   (c) 4 times (d) unchanged
11. Unit of work done is
   (a) Joule (b) Newton meter
   (c) Calorie (d) Both (a) and (b)
12. Kinetic energy of a body moving with speed 10 m/s is 30J. If its speed becomes 30 m/s, its kinetic energy will be
   (a) 10 J (b) 90 J
   (c) 180 J (d) 270 J
13. When you compress a coil spring you do work on it. The elastic potential energy
   (a) increases (b) decreases
   (c) disappears (d) remains the same
14. No work is done when
   (a) a nail is plugged into a wooden board
   (b) a box is pushed along a horizontal floor
   (c) there is no component of force parallel to the direction of motion
   (d) there is no component of force normal to the direction of force
15. Work done by a force can be
   (a) only positive
   (b) only negative
   (c) both positive and negative
   (d) None of these
16. The work done against gravity in moving the block a distance s up the slope is



   (a) mh (b) mgs
   (c) ms (d) mgh
17. Potential energy of your body is minimum when
   (a) you are standing
   (b) you are sitting on a chair
   (c) you are sitting on the ground
   (d) you lie down on the ground
18. A body of mass 2 kg is dropped from a height of 1 m. Its kinetic energy as it touches the ground is
   (a) 19.6 N (b) 19.6 J
   (c) 19.6 kg (d) 19.6 m
19. Negative value of work done indicates that
   (a) force and displacement are in the same direction
   (b) more than one force is acting on the object
   (c) displacement and force are in opposite directions
   (d) Both (b) and (c)
20. Work done is zero when
   (a) force and displacement of the body are in the same direction
   (b) force and displacement of the body are in the opposite direction
   (c) force acting on the body is perpendicular to the direction of the displacement of the body
   (d) None of these
21. The energy of 4900 J was expanded in lifting a 50 kg mass. The mass was raised to a height of –
   (a) 10 m (b) 98 m
   (c) 960 m (d) 245000 m
22. When a stone is thrown upward to a certain height, it possesses
   (a) potential energy (b) kinetic energy
   (c) wind energy (d) sound energy
23. Capacity of doing work is termed as
   (a) pressure (b) energy
   (c) force (d) displacement
24. A fast wind can turn the blades of a windmill because it possesses –
   (a) potential energy (b) kinetic energy
   (c) chemical energy (d) heat energy
25. If a stone of mass m falls a vertical distance d, the decrease in gravitational potential energy is –
   (a) mg/d (b) $md^2/2$
   (c) mgd (d) md/g
26. A block of weight W is pulled a distance ℓ along a horizontal table. The work done by the weight is –
   (a) Wℓ (b) 0
   (c) Wgℓ (d) Wℓ/g
27. Unit of energy is
   (a) same as the unit of work
   (b) joule
   (c) Both (a) and (b)
   (d) Neither (a) nor (b)
28. The proper care and maintenance of machines require
   (a) to make them good looking
   (b) for preserving them for future
   (c) for their efficient and longer use
   (d) None of these
29. Solar cookers are used
   (a) to cook our food
   (b) in artificial satellites
   (c) converting into electrical energy
   (d) in drying clothes and other materials
30. What is the sign of the work done by gravity on a man standing on a platform?
   (a) Zero
   (b) Positive
   (c) Negative
   (d) Depends on the particular situation
31. A body at rest can have –
   (a) speed (b) energy
   (c) momentum (d) velocity
32. What is the sign of the work performed on an object in uniform circular motion?
   (a) Zero
   (b) Positive
   (c) Negative
   (d) Depends on the particular situation

33. A constant force of 10 N causes a box to move at a constant speed of 2 m/s. How much work is done in 10 seconds?
(a) 200 J (b) 50 J
(c) 10 J (d) 2 J

34. An object of 2 kg is moving with a velocity of 5 m/s. If its velocity is doubled, the kinetic energy will become
(a) 100 J (b) 25 J
(c) 200 J (d) 2.5 J

35. A mass is kept stationary by an external force. All of the following are true except –
(a) the point of application of the force does not move
(b) no work is done on the mass
(c) there is no net force on the mass
(d) the external force may perform work on the mass

36. A bird flying in the sky has –
(a) K.E. only
(b) P.E. only
(c) neither K.E. nor P.E.
(d) both K.E. and P.E.

37. The sum of the change in kinetic and potential energy is always
(a) zero (b) positive
(c) negative (d) None of the above

38. A man of a mass 80 kg runs up a staircase in 12 seconds. Another man B of mass 60 kg runs up the same staircase in 11 seconds. The ratio of powers of A and B is –
(a) 11 : 12 (b) 11 : 9
(c) 12 : 11 (d) 9 : 11

39. A lorry and a car moving with the same K.E. are brought to rest by applying the same retarding force, then –
(a) lorry will come to rest in a shorter distance
(b) car will come to rest in a shorter distance
(c) both come to rest in a same distance
(d) None of the above

40. A weight-lifter lifts 200 kg from the ground to a height of 2 metre in 9 second. The average power generated by the man is
(a) 15680 W (b) 3920 W
(c) 1960 W (d) 980 W

41. Gravitational potential energy of an object will
(a) increase by increasing the path along which the object is moved
(b) decrease by increasing the path along which the object is moved
(c) not effected by changing the path, provided the overall height is same
(d) None of these

42. Total mechanical energy of an object is
(a) Potential energy + Kinetic energy = Constant
(b) $mgh + \frac{1}{2}mv^2$ = constant
(c) Both (a) and (b)
(d) None of these

43. Rate of doing work is termed as
(a) force (b) mechanical energy
(c) power (d) momentum

44. 1 kilowatt = -----
(a) 1000 W (b) 1000 J s^{-1}
(c) 1000 N m s^{-1} (d) All of these

45. Commercial unit of power is kilowatt-hour (kW h)
(a) 1 kW h = 3.6×10^6 J
(b) 1 kW h is the energy consumed in one hour at the rate of 1000 J s^{-1}
(c) 1 kW h = 1 unit of electrical energy
(d) All these statements are correct

46. An electrical appliance of 500 W is used for 5 hours per day. Energy consumed in 30 days will be
(a) 2.5 kW h (b) 25 kW h
(c) 75 kW h (d) None of these

47. Sun is said to be the ultimate source of energy. Solar energy gets transformed into
(a) chemical energy during photosynthesis
(b) heat energy in drying food grains
(c) electrical energy in solar cells
(d) All of these

48. The potential energy of a freely falling object decreases progressively
(a) The law of conservation of energy is violated
(b) Potential energy gets converted into kinetic energy progressively
(c) Sum of Potential Energy and Kinetic Energy at any point during the free fall remains constant
(d) Both (b) and (c)

49. When a freely falling object hits the ground, its kinetic energy is
(a) Converted into heat energy
(b) Used to form a crater in the ground
(c) Collides and then rebounds
(d) Any of the three are possible

50. If velocity of a body is twice of previous velocity, then kinetic energy will become –
(a) 2 times (b) 1/2 times
(c) 4 times (d) 1 times

51. If the K.E. of a body is increased by 300%, its momentum will increase by –
(a) 100% (b) 150%
(c) $\sqrt{300}$% (d) 175%

52. A ball of mass 2 kg and another of mass 4 kg are dropped together from a 60 feet tall building. After a fall of 30 feet each towards earth, their respective kinetic energies will be in the ratio of –
(a) $\sqrt{2} : 1$ (b) 1 : 4
(c) 1 : 2 (d) $1 : \sqrt{2}$

53. A man of weight 60 kg wt. takes a body of mass 15 kg at a height 10m on a building in 3 minutes. The efficiency of mass is –
(a) 10% (b) 20%
(c) 30% (d) 40%

[redacted]

Hints & SOLUTIONS

1. (c) 2. (d) 3. (d)
4. (d) Scientific concept of work suggest that a work is said to be done if a force acts on an object and the object gets displaced.
5. (c) 6. (d)
7. (a) Work done is defined as the product of force and displacement.
8. (d) 9. (a) 10. (b)
11. (d) Unit of work done is Joule or Newton meter.
12. (d) 13. (a) 14. (d)
15. (b) Work done by a force can be both negative and positive.
16. (d) 17. (d) 18. (b)
19. (d) Negative value of work indicates that more than one force is acting on the object. The displacement and force are in opposite directions.
20. (c) 21. (a) 22. (a)
23. (b) Energy is the capacity of doing work.
24. (a) 25. (c) 26. (b)
27. (c) Unit of energy is same as the unit of work, i.e. Joule.
28. (c) 29. (a) 30. (a) 31. (b)
32. (a) 33. (a) 34. (b) 35. (d)
36. (d) 37. (a) 38. (b) 39. (c)
40. (d)
41. (c) The gravitational potential energy is not affected by the path followed provided the overall height is same.
42. (c) Mechanical energy = Potential energy + Kinetic energy
43. (c) Rate of doing work is called power.
44. (d) 1 kilowatt = 1000 W = 1000 J s^{-1} = 1000 N m s^{-1}.
45. (d) 1 kW h = 3.6×10^6 J; 1 kW h is the energy consumed in one hour at the rate of 1000 J s^{-1}. 1 kW h is commonly referred to as a unit of electrical energy.
46. (c) Energy consumed = Work done = 0.5 kW × 5 hours × 30 days = 75 kW h.
47. (d) Solar energy can be transformed into chemical, electrical, heat or mechanical energy by using suitable equipments.
48. (d) Potential energy gets converted into kinetic energy progressively and the sum of potential energy and kinetic energy at any point during the free fall remains constant.
49. (c) The change in momentum on collision is likely to make the object rebound. The momentum of the object can cause a crater in the ground. The kinetic energy will be converted into heat energy.
50. (c) Kinetic energy = $\frac{1}{2}mv^2$ $\therefore$ K.E. $\propto v^2$

    If velocity is doubled then kinetic energy will become four times.
51. (a) Let initial kinetic energy, $E_1 = E$

    Final kinetic energy, $E_2 = E + 300\%$ of $E = 4E$

    As $p \propto \sqrt{E} \Rightarrow \frac{p_2}{p_1} = \sqrt{\frac{E_2}{E_1}} = \sqrt{\frac{4E}{E}} = 2 \Rightarrow p_2 = 2p_1$

    $\Rightarrow p_2 = p_1 + 100\%$ of p_1

    i.e. momentum will increase by 100%.
52. (c) Kinetic energy = $\frac{1}{2}mv^2$

    As both balls are falling through same height therefore they possess same velocity.

    But KE $\propto$ m (If v = constant)

    $\therefore \frac{(KE)_1}{(KE)_2} = \frac{m_1}{m_2} = \frac{2}{4} = \frac{1}{2}$
53. (b) Efficiency

    $\eta = \frac{\text{useful work}}{\text{spent work}} = \frac{15gh}{(15+60)\,gh} = \frac{15}{75} = \frac{1}{5} = 20\%$

Chapter 4 Sound, Oscillations, Heat & Thermodynamics

SOUND

Sound is a form of energy that we hear. A vibrating object i.e., anything that moves back and forth, to-and-fro from side to side, in and out and up and down produces sound, as the object (vibrating) has a certain amount of energy. Sound requires material medium-a solid, a liquid or a gas to travel.

If there is no medium to vibrate then no sound is possible, sound cannot travel in a vacuum. Air is a poor conductor of sound compared with solids and liquids.

Wave

Due to the vibratory motion of the particles of the medium a periodic disturbance is produced in a material medium. This is called a wave. In the absence of medium solid, liquid or gas sound wave is not being propagated but light (electromagnetic) waves travel through the vacuum.

Types of Waves

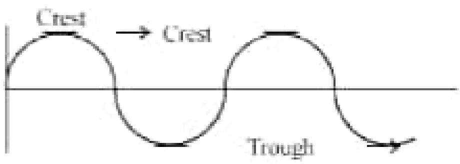
On the basis of the requirement of medium, waves are of two types

Mechanical Waves

A mechanical wave is a periodic disturbance which requires a material medium for its propagation. The properties of these waves depend on the medium so they are known as *elastic waves*, such as sound-waves, water waves, waves in stretched string etc. On the basis of motion of particles the mechanical waves are classified into two parts.

Transverse wave: When the particles of the medium vibrate in a direction perpendicular to the direction of propagation of the wave, the wave is known as the *transverse wave*. For example, waves produced in a stretched string, waves on the surface liquid.

These waves travel in the form of crests and troughs. These waves can travel in solids and liquids only.



Longitudinal wave: When the particles of the medium vibrate along the direction of propagation of the wave then the wave is known as the longitudinal wave. For example sound wave in air, waves in a solid rod produced by scrabbing etc.

These waves travel in the form of compressions and rarefactions. These waves can travel in solids, liquids and gases.

Electromagnetic Waves

The waves which do not require medium for their propagation are called electromagnetic waves. This means that these waves can travel through vacuum also. For example, light waves, X-rays, g-rays, infrared waves, radio waves, microwaves, etc. These waves are transverse in nature.

Difference between sound waves and electromagnetic waves

- Sound waves are longitudinal whereas electromagnetic waves are transverse.
- Sound waves travel at a speed of 340 m/s whereas electromagnetic waves travel at a speed of 3×10^8 m/s
- Sound waves do not pass through a vacuum but electromagnetic waves (light) do.

Basic Terms Related to Sound Waves

Time Period (T): Time taken in one complete vibration (full cycle) is called it's time period

Frequency (n): Frequency is defined as the number of vibrations (or oscillations) completed by a particle in one second.

Frequency, $v = \frac{1}{T}$

Its SI unit is hertz

Wavelength (l): The distance travelled by the wave during the time in which any one particle of the medium completes one vibration about its mean position.

Amplitude: The maximum displacement of the wave particle from its mean position.

Wave Velocity: The distance i.e., wavelength (l) covered by a wave in one time period

Therefore, Wave velocity $= \frac{\text{wavelength}}{\text{time taken}}$

or $v = \lambda/T = v\lambda$

or Wave velocity = Frequency × Wavelength

Speed of sound is maximum in solids and minimum in gas.

Factors Affecting the Speed of Sound

Temperature: Speed of sound is directly proportional to the square root of absolute temperature i.e.,.

Pressure: The speed of sound is independent of pressure

Density: Speed of sound is inversely proportional to the square root of density of the gas.

$$v = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow v \propto \frac{1}{\sqrt{\rho}} \text{ or, } \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Humidity: Humid air is lighter than dry air that is why speed of sound increase as humidity increases.

Characteristics of Sound

Pitch

Pitch is the sensation (brain interpretation) of the frequency of an emitted sound and is the characteristic which distinguishes a shrill (or sharp) sound from a grave (or flat) sound. Faster the vibration of the source, higher is the frequency and higher is the pitch. Similarly low pitch sound corresponds to low frequency. A high pitch sound is called a shrill sound (humming of a bee, sound of guitar).

A low pitch sound is called a hoarse sound (roar of a lion, car horn, etc.)

The pitch of female voice is higher than the pitch of male voice.

Loudness

Loudness or softness of a sound wave is the sensation that depends upon its amplitude. The loudness of sound is a measure of the sound energy reaching the ear per second. When we strike a table top with more force, it vibrates and produces loud sound waves which have more amplitude.

The loudness depends on intensity as well as upon the sensitiveness of ear.

Loudness of sound is co-related with the sound level measured in **decible (dB)**.

Sound above 80dB is unpleasant for human ear.

Quality (Timbre)

Quality or timbre of a sound wave is that characteristic which helps us in distinguishing one sound from another having same pitch and loudness. We recognise a person (without seeing) by listening to his sound as it has a definite quality. *(A pure sound of single frequency is called a tone).* An impure sound produced by mixture of many frequencies is called a **note**. It is pleasant to listen. Notes of the same pitch played upon different musical instruments are distinguished from each other by their quality. The quality of a note depends on the wave form. The waves produced by different instruments differ in their forms.

Reflection of Sound

It is a common experience that when we shout into a well or inside an empty hall, or inside a dome, we hear our own sound after a short time. It happens because our sound is reflected from the walls. When sound waves strike a surface, they return back into the same medium. This phenomenon is called reflection of sound.

Laws of Reflection of sound

- Angle of incidence Di is equal the angle of reflection Dr
- The incident wave, the reflected wave and the normal all lie in the same plane.

Echo

The Phenomenon of hearing back our own sound is called an *echo*. It is due to successive reflection from the surfaces of obstacles.

Conditions for the formation of Echoes

- The minimum distance between the source of sound and the reflecting body should be 17.2 metres.
- The wavelength of sound should be less than the height of the reflecting body.
- The intensity of sound should be sufficient so that it can be heard after reflection.

Science in Action

- **Speaking tube or megaphone:** You must have seen in fairs or tourist spots, people using megaphones addressing a group of people. Megaphone is simply a horn-shaped tube. The sound waves are prevented from spreading out by successive reflections and are confined to the air in the tube. For the same reason, loud speakers also have horn-shaped.

Reverberation

Persistence of sound after its production is stopped, is called reverberation. When a sound is produced in a big hall, its waves reflect from the walls and travel back and forth. Due to this, energy does not reduce and the sound persist.

Range of Hearing

Normal human ears can hear the sound of frequency 20 Hz to 20,000 Hz. Sound of frequency less than 20 Hz is called **infrasonic**. Sound of frequency greater than 20,000 Hz is called **ultrasonic**. Children under the age of five and dogs, owls can hear upto 25 kHz. Whales and elephants produce sound in the infrasonic range. Rhinoceroes make communication between themselves by using a frequency as low as 5 Hz.

Handy Facts

Supersonic refers to the speed greater than speed of sound.

Ultrasound

Frequencies higher than 20,000 Hz are called ultrasound. Ultrasound can be produced by Galton's whistle. Some animals, such as dolphins can produce ultrasound. Bats can produce and hear ultrasound. On being high frequency waves, ultrasound possesses high intensity, and therefore can penetrate any solid or liquid medium.

SONAR

SONAR stands for **so**und **n**avigation **a**nd **r**anging. SONAR is a device which is used to find depth of sea or to detect the position of submarine hidden inside water. Sonar consists of a transmitter and a detector.

Interference of Waves

When two waves of equal frequency and nearly equal amplitude travelling in same direction having same state of polarisation in medium superimpose, then intensity is different at different points. At some points intensity is large, whereas at other points it is nearly zero.

For Constructive Interference (Maximum Intensity)

Phase difference, $\phi = 2n\pi$ or path difference $= n\lambda$

where $n = 0, 1, 2, 3, \ldots$

$$v = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow v \propto \frac{1}{\sqrt{\rho}} \text{ or, } \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

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For Constructive Interference (Maximum Intensity)

Phase difference, $\phi = 2n\pi$ or path difference $= n\lambda$

where $n = 0, 1, 2, 3, ...$

Avogadro's Law: When the pressure and temperature are kept constant, the volume is directly proportional to the number of moles of the ideal gas in the container.

i.e., V ∝ n (at constant pressure and temperature)

Thermal Expansion

When a body (almost all) is heated it expands. The expansion can take place in the length, area or volume of the body. Depending upon the expansion in length, area or volume we have three types of expansion

Linear Expansion

Let l_1 be the length of a wire at temperature 'q_1' when temperature is increased to q_2, length increases to l_2 then

$$\alpha = \frac{\Delta l}{l_1 \Delta\theta} \quad \text{or} \quad l_2 = l_1(1 + \alpha\Delta\theta)$$

($\Delta l = l_2 - l_1$ change in length & change in temperature $\Delta\theta = \theta_2 - \theta_1$)

Where α is **coefficient of linear expansion**. Its unit is /°C or /K. It depends upon the nature of material. The value of 'a' also depends on temperature but very slightly.

Superficial or Areal Expansion:

Increase in surface area of a solid when temperature is increased. If A_1 and A_2 be the surface area at temperature q_1 and q_2 respectively then

$$\beta = \frac{\Delta A}{A_1 D\theta} \text{ or, } A_2 = A_1(1 + \beta\Delta\theta)$$

'β' is **coefficient of superficial expansion** of a solid. Its unit is /°C and /K, it depends upon nature of material.

Cubical or Volume Expansion:

Increase in volume of a substance on heating. If V_1 and V_2 are volumes of a substance at temperature q_1 and q_2 respectively, then

$$\gamma = \frac{\Delta V}{V_1 \Delta\theta} \text{ or, } V_2 = V_1(1 - gDq)$$

Where 'γ' is **coefficient of cubical expansion** of solid. Its unit is /°C or /K and it depends upon the nature of material.

The relation between (α, β and γ is $\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$

$\Rightarrow \alpha : \beta : \gamma = 1 : 2 : 3$)

> ***Science in Action***
> - A small gap is left between the iron nails of railway tracks.
> - Space is left between the girders used for supporting bridges.
> - Clock pendulums are made of invar. Invar has extremely small temperature coefficient of expansion, so the length of invar pendulum does not change with the change of season. i.e., temperature.

Expansion of Liquids

When we heat a liquid which is kept inside a container then liquid as well as the container both expand. In this case the observed expansion of liquid will be apparent expansion. But if the container were not expand then the expansion will be real expansion.

Coefficient of real expansion γ_r

$$= \frac{\text{real increase in volume}}{\text{originalvolume} \times \Delta\theta}$$

Coefficient of apparent expansion γ_a

$$= \frac{\text{apparent increase in volume}}{\text{originalvolume} \times \Delta\theta}$$

If γ_s is coefficient of volume expansion of material of container then

$$\gamma = \gamma_a + \gamma_s$$

Anomalous Expansion of Water

Almost all liquids expand on heating but water when heated from 0°C to 4°C its volume decreases and hence density increases until its temperature reaches 4°C as its density is maximum at 4°C and on further heating its density decreases. This behaviour of water is called anomalous behaviour of water.

This allows aquatic animals to remain alive and move freely near the bottom.

Calorimetry

We know that there is spontaneous transfer of heat from a hot body to colder body. If heat exchange with the surrounding is negligible then the total heat lost by a hot body is always equal to the heat gained by the cold body. this is the **principle of calorimetry or, law of mixture.**

Specific Heat Capacity

When we supply heat to a body, its temperature rises. If m is mass, Dq is temperature rise and Q is the heat supplied, then

$$Q \propto M \Rightarrow Q \propto \Delta\theta \text{ or } Q = Ms\Delta\theta \Rightarrow s = \frac{Q}{M\Delta\theta}$$

Where 's' is constant called *specific heat* which depends upon the nature of material and its surrounding.

Specific heat capacity of a material is equal to the heat required to raise temperature of unit mass from 14.5°C to 15.5°C

Molar Heat Capacity and Heat Capacity

Molar heat capacity of a substance is the amount of heat required to raise the temperature of one mole of a substance by unit degree.

$$s_m = \frac{Q}{n\Delta\theta} \quad n = \text{number of moles}$$

Heat capacity of a substance is the amount of heat required to raise temperature of a body by unit degree. It is represented by C, its unit is J/°C or cal/°C. Heat capacity depends upon nature of material and its mass.

$$\text{Heat capacity, } C = \frac{Q}{\Delta\theta} = ms$$

Water Equivalent and Latent Heat

Water Equivalent of a body is defined as the mass of water which has the same heat capacity as that of the body. It is represented by W.

Latent Heat or Hidden Heat: When state of a substance changes, change of state takes place at constant temperature (m.pt. or B. pt.) heat is released or absorbed and is given by

For Destructive Interference (Minimum Intensity)

Phase difference, $\phi = (2n+1)\pi$, or path difference $= (2n-1)\frac{\lambda}{2}$;

where n = 0, 1, 2, 3, ...

Stationary Longitudinal Waves and air columns

When two longitudinal waves of same frequency and amplitude travel in a medium in opposite directions then by superposition, standing waves are produced. These waves are produced in air columns in cylindrical tube of uniform diameter. These sound producing tubes are called **organ pipes.**

Vibration of Air Column in Closed Organ Pipe

The tube which is closed at one end and open at the other end is called closed organ pipe.

If λ is length of pipe and λ be the wavelength and v be the velocity of sound in organ pipe then,

Case (a), $L = \frac{\lambda}{4} \Rightarrow \lambda = 4L \Rightarrow n_1 = \frac{v}{\lambda} = \frac{v}{4L}$

Fundamental frequency or first harmonic.

Case (b), $L = \frac{3\lambda}{4} \Rightarrow \lambda = \frac{4L}{3} \Rightarrow n_2 = \frac{v}{\lambda} = \frac{3v}{4L}$

First overtone or third harmonic

Case (c), $L = \frac{5\lambda}{4} \Rightarrow \lambda = \frac{4L}{5} \Rightarrow n_3 = \frac{v}{\lambda} = \frac{5v}{4L}$

Second overtone or fifth harmonic.

Vibration of Air Column in Open Organ Pipe

The tube which is open at both ends is called an open organ pipe.

Case (a), $L = \frac{\lambda}{2} \Rightarrow \lambda = 2L \Rightarrow n_1 = \frac{v}{\lambda} = \frac{v}{2L}$

Fundamental frequency or first harmonic

Case (b), $L = \frac{2\lambda}{2} \Rightarrow \lambda = \frac{2L}{2} \Rightarrow n_2 = \frac{v}{\lambda} = \frac{2v}{2L}$

First overtone or second harmonic.

Case (c), $L = \frac{3\lambda}{2} \Rightarrow \lambda = \frac{2L}{3} \Rightarrow n_3 = \frac{v}{\lambda} = \frac{3v}{2L}$

When open organ pipe vibrate in m^{th} overtone then

$L = (m+1)\frac{\lambda}{4}$ so, $\lambda = \frac{4L}{m+1} \Rightarrow n = (m+1)\frac{v}{2L}$

Second overtone or third harmonic.

Hence frequency of overtones i.e. of both odd and even harmonies and is given by the relation

$n_1 : n_2 : n_3$ .... = 1 : 2 : 3.........

BEATS

When two sound waves of nearly same frequency are produced simultaneously, then the intensity of resultant sound wave increases and decreases with time. This change in the intensity of sound is called as the phenomenon of '*beats*'.

The time interval between two successive beats is called *beat period* and the number of beats per second is called the *beat frequency*.

If f_1 and f_2 are the frequencies ($f_1 > f_2$) of the two waves, then the beat frequency

$$b = f_1 - f_2$$

Important Features

- At frequency difference greater than about 6 or 7 Hz, we no longer hear individual beats.

SIMPLE HARMONIC MOTION (S.H.M.)

Oscillatory motion in which the acceleration of the particle is directly proportional to the displacement and directs towards a fixed point in a direction opposite to displacement is called simple harmonic motion abbreviated as S.H.M.

If a particle performs oscillatory motion such that its acceleration (a) and displacement (x) are related as below

$a \propto -x,$

then the motion of particle is simple harmonic.

The force (F) acting on the particle is obviously proportional to x and directs in opposite to it. i.e.,

$F \propto -x$

or $F = -kx$, where k is a constant force law

This force F is known as the restoring force as it always restore the position of the particle.

Handy Facts

An oscillatory motion is always periodic i.e., the motion that repeats itself in equal intervals of time but a periodic motion may not be oscillatory.

Equation of S.H.M.

The equation of S.H.M. represents the displacement (x) of the particle at any time (t).

It is generally given by

$$x = A\sin(\omega t + \phi) \quad \text{or} \quad x = A\cos(\omega t + \phi)$$

Here, A = amplitude and ω = angular frequency

ϕ = phase constant or initial phase

Amplitude (A): It is the maximum distance on the either side of the mean position of oscillating particle. It is represented by A, its S.I. unit is metre (m).

Phase: Phase of a vibrating particle at any instant is the state of the vibrating particle regarding its displacement and direction of vibration at that particular instant.

The *cosine* in equation $x = A\cos(\omega t + \phi_0)$ gives the phase of oscillation at time t.

Velocity

The displacement of a particle executing S.H.M. is given by

$x = A\sin(\omega t + \phi)$

Time period: It is the time taken by the oscillating particle to complete one oscillation. It is represented by T.

Kinetic energy: A particle executing SHM possesses kinetic energy by virtue of its motion.

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(A^2 - x^2) \quad (v = \omega\sqrt{A^2 - x^2})$$

Potential energy : A particle executing SHM possesses potential energy due to its displacement from its mean position.

$$P.E = \frac{1}{2}kx^2 \Rightarrow P.E = \frac{1}{2}m\omega^2x^2 \quad (k = m\omega^2)$$

At mean position, $x = 0 \Rightarrow$ P.E. = 0

At extreme position, $x = A$

$$\Rightarrow (P.E)_{max} = \frac{1}{2} m\omega^2 A^2 = \frac{1}{2} k\omega^2$$

Simple Pendulum

An ideal simple pendulum consists of a heavy point mass (bob) suspended by a weightless, inextensible and perfectly flexible string from a rigid support about which it is free to oscillate.

Time period of a simple pendulum,

$T = 2\pi\sqrt{\frac{l}{g}}$ where, l = length of pendulum

and g = acceleration due to gravity.

Time period of second pendulum is 2 seconds.

Resonance

The phenomenon of increase in amplitude when the driving force is close to the natural frequency of the oscillator.

Science in Action

- Resonance-while swinging in a swing to greater heights lies in the synchronisation of the rhythm of pushing against the ground with the natural frequency of the swing.
- Marching soldiers break steps while crossing a bridge.

HEAT AND THERMODYNAMICS

Heat is a form of energy which is responsible for the change in thermal condition of a body. It is also described as energy flow due to difference in temperature. The branch of science which deals with the conversion of heat into mechanical work and vice-versa is *Thermodynamics*.

Heat

Heat or thermal energy is the sum of all types of kinetic energies (translational, vibrational, rotational) of all the molecules of the body.

The SI unit of heat energy is joule (J), practical unit of heat energy is Calorie. "One calorie is the amount of heat required to raise temperature of one gram of water from 14.5°C to 15.5°C."

1 Calorie = 4.186 joule

Science in Action

The relative humidity during rainy season increases and the rate of vaporisation decreases. This is why clothes dry earlier in winter than in rainy season.

Temperature

Temperature is defined as the degree of hotness or coldness of a body. To measure temperature above 800°C, we use **Pyrometer**.

Absolute Temperature

The lowest temperature of –273.16°C at which a gas is supposed to have zero volume and zero pressure and at which entire molecular motion stops is called absolute zero temperature. A new scale of temperature starting with –273.16°C by Lord Kelvin as zero. This is called Kelvin scale or absolute scale of temperature.

T(K) = t°C – 273.16

Temperature Scale

In order to measure the temperature, two-points are fixed, the lower fixed point is ice point and upper fixed point is boiling point of water.

Celsius Scale (°C): This scale was designed by Andre Celsius in 1710. In this scale the melting point of ice is taken as 0°C and the boiling point of water is taken as 100°C and the space between the two points is divided into 100 equal parts.

Fahrenheit Scale (°F): This scale was designed by Gabriel Fahrenheit in 1717. In this scale the melting point of ice is taken as 32°F and the boiling point of water is taken as 212°F and the space between the points is divided equally into 180 parts.

Kelvin Scale (K): This was designed by Kelvin. In this scale the melting point of ice is taken as 273K and boiling point of water is taken as 373K and the space between the points is divided equally into 100 parts.

Relation between various temperature scales

$$\left(\frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5}\right)$$

Handy Facts

- At –40° temperature, the celsius and fahrenheit scales read the same.
- At 574.25° temperature, the fahrenheit and kelvin scales read the same.

Triple Point of Water

The state at which three phases of water-ice, liquid water and water vapour are equally stable and co-exist in equilibrium.

It is unique because it occurs at a specific temperature of 273.16 K and a specific pressure of 0.46 cm of Hg column.

Humidity

Absolute Humidity : It is the amount of water vapour present in a unit volume of air.

Relative humidity: It is defined as the ratio of the amount of water vapour present in a given volume of air at a given temperature to the amount of water vapour required to saturate the same volume of air at the same temperature.

Science in Action

The relative humidity during rainy season increases and the rate of vaporisation decreases. This is why clothes dry earlier in winter than in rainy season.

Ideal-Gas Equation

The equation PV = nRT, where n = no. of moles in the sample of gas, R = Universal gas constant

(= 8.31 J mol^{-1} K^{-1}) is known as *ideal-gas equation*.

It is the combination of following three laws.

Boyle's Law: When temperature is held constant, the pressure is inversely proportional to volume.

i.e., P ? $\frac{1}{V}$ (at constant temperature)

Charle's Law: When the pressure is held constant, the volume of the gas is directly proportional to the absolute temperature.

i.e., $V \propto T$ (at constant pressure)

$Q = mL$, where L is latent heat. The S.I. unit of latent heat is J/kg.

Latent heat of fusion or melting (L_f): It is the amount of heat required to change unit mass of solid into liquid state at its melting point. It is represented by L_f. For ice its value is 80 cal g^{-1}

$$Q = mL_f$$

Latent heat of vaporisation or boiling (L_v): It is the amount of heat required to change unit mass of liquid into its vapors at its boiling point. It is represented by L_v

For water $L_v = 540$ cal g^{-1}

$$Q = mL_v$$

Sublimation: It is the conversion of a solid directly into vapours.

$$\text{Solid} \xrightarrow{\text{heat}} \text{Vapour}$$

Regelation

The phenomenon in which ice melts when pressure is increased and again freezes when pressure is removed is called *regelation*.

> ***Science in Action***
> - Skating is possible due to regelation. Water layer below the skates is formed due to the increase of pressure and it acts as a lubricant.
> - By pressing snow in our hand, we can transform it into a snow-ball.

Heat Transfer

Heat energy can be transferred from a body at higher temperature to a body at lower temperature by three different ways viz. conduction, convection and radiation.

Conduction

Conduction is the process in which heat is transmitted from one point to the other through the substance without the actual motion of the particles. When one end of a metal is heated, the molecules at the hot end start vibrating with higher amplitudes (kinetic energy) and transmit this K.E. to the next molecule and so on. However, the molecules still remain in their mean positions of equilibrium. This process of conduction is prominent in the case of solids.

Convection

Convection is the process in which heat is transmitted from one place to the other by the actual movement of the vibrating particles. It is prominent in the case of liquids and gases.

Land and **sea breezes** and **trade winds** are formed due to convection. Convection plays an important part in ventilation, gas filled electric lamps and heating of buildings by hot water circulation.

It is the process of transfer of heat in a fluid by the movement of the fluid itself.

Radiation

Radiation is the process in which heat is transmitted from one place to the other directly without the necessity of any intervening medium. We get heat radiations directly from the sun without affecting the intervening medium. Heat radiations can pass through vacuum. Heat radiations are a part of the electromagnetic spectrum.

Radiation has the following properties

- Radiant energy travels in straight line and when some object is placed in the path, it's shadow is formed at the detector.
- It is reflected and refracted or can be made to interfere. The reflection or refraction are exactly as in case of light.
- It can travel through vacuum.
- Intensity of radiation follows the law of inverse square.
- Thermal radiation can be polarised in the same way as light by transmission through a nicol prism.

Thermal Conductivity

It is the measure of ability of the solid to conduct heat through it. Examples: silver, copper, etc. are good conductors of heat and glass, wood are bad conductors of heat.

The coefficient of thermal conductivity (K) is defined as the amount of heat flowing in unit time across the opposite faces of a cube of side having unit length maintained at unit temperature difference.

$$\text{Coefficient of thermal conductivity } K = \frac{(\Delta Q / \Delta t)}{(A dT / \Delta x)}$$

> ***Science in Action***
> - During the winter season, birds often swell their feathers, this encloses the air between the body and feathers and thus stops the flow of heat from its body to the surroundings.
> - Metallic handles of doors during winter season appear colder as it is a good conductor, heat flows from the body to the handle.

Kirchhoff's Law

According to Kirchhoff's law the ratio of emissive power to absorptive power corresponding to the certain wavelength is the same for all bodies at a given temperature and is equal to the emissive power of a black body at that temperature.

Wien's Displacement Law

According to Wien's displacement law, wavelength corresponding to highest intensity (λ_m) is inversely proportional to the absolute temperature of the body.

Black Body

A black body absorbs the entire thermal radiation incident on it. Practically there is no body which absorbs 100% radiations incident on it. Ferry designed a black body which a spherical enclosure painted black from inside with a small hole in the wall.

Any radiation through this hole goes inside and get absorbed after multiple reflections. There is cone directly opposite to the hole due to which incident radiation is not reflected back through the hole.

Thermodynamic Processes

Thermodynamic process is said to take place if some change occurs in the state of a thermodynamic system, i.e. the thermodynamic variables of the system – pressure, volume, temperature and entropy change with time.

In practice, the following types of thermodynamic processes can take place :

Isothermal process: A thermodynamic process that takes place at constant temperature.

Isobaric process: A thermodynamic process that takes place at constant pressure.

Isochoric process: A thermodynamic process that takes place at constant volume.

Adiabatic process: A thermodynamic process in which no heat enters or leaves the system.

Cyclic process: A thermodynamic process in which the system returns to its original state.

Laws of Thermodynamics

Zeroth Law of Thermodynamics

If objects A and B are separately in thermal equilibrium with a third object C then objects A and B are in thermal equilibrium with each other.

First Law of Thermodynamics

If some quantity of heat is supplied to a system capable of doing external work, then the quantity of heat absorbed by the system is equal to the sum of the increase in the internal energy of the system and the external work done by the system.

i.e., $\Delta Q = \Delta U + \Delta W$

The first law of thermodynamics is essentially a restatement of the law of conservation of energy i.e., energy can neither be created nor be destroyed but may be converted from one form to another.

Second Law of Thermodynamics

Kelvin-Planck statement : It is impossible for an engine working between a cyclic process to extract heat from a reservoir and convert completely into work. In other words, 100% conversion of heat into work is impossible.

Heat Engines

Heat engine is a device which converts heat energy into work. A heat engine, in general, consists of three parts :

- A source or high temperature reservoir at temperature T_1.
- A working substance.
- A sink or low temperature reservoir at temperature T_2.

The efficiency of internal combustion engine is approximately 40% to 60%.

Refrigerators and Heat Pumps

A **refrigerator** is the reverse of a heat engine. A heat pump is the same as a refrigerator.

Carnot Theorem

No irreversible engine (I) can have efficiency greater than Carnot reversible engine (R) working between same hot and cold reservoirs.

Exercise

DIRECTIONS: *This section contains multiple choice questions. Each question has choices (a), (2), (3) and (4) out of which only one is correct.*

1. Which of the following is carried by the waves from one place to another ?
   (a) Mass (b) Velocity
   (c) Wavelength (d) Energy
2. The velocity of sound is largest in
   (a) water (b) air
   (c) metal (d) vacuum
3. The ratio of the speed of a body to the speed of sound is called
   (a) Sonic index (b) Doppler ratio
   (c) Mach number (d) Refractive index
4. Sound is transmitted through a medium. The medium can be
   (a) Solid (b) Liquid
   (c) Gas (d) Solid, liquid or gas
5. The speed of sound of a wave of frequency 200 Hz in air is 340 m/s. The speed of sound of wave of frequency 400 Hz in same air is
   (a) 340 m/s (b) 680 m/s
   (c) 170 m/s (d) 3×10^8 m/s
6. Ultrasonic waves have frequency
   (a) below 20 Hz
   (b) between 20 and 20,000 Hz
   (c) only above 20,000 Hz
   (d) only above 20,000 MHz
7. One hertz is equivalent to
   (a) one cycle per second
   (b) one second
   (c) one meter per second
   (d) one second per meter
8. A particle of the medium in contact with the vibrating object is first displaced from its equlibrium position. It exerts a force on the adjacent particle and displaces it from rest. After displacing the adjacent particle the first particle
   (a) Comes back to its original position
   (b) Goes and displaces the other particle
   (c) Travels till the end of the medium
   (d) None of these
9. If you are at open-air concert and someone's head gets between you and the orchestra, you can still hear the orchestra because
   (a) sound waves pass easily through a head
   (b) a head is not very large compared with the wavelength of the sound
   (c) the sound is reflected from the head
   (d) the wavelength of the sound is much smaller than the head
10. An underwater explosion is caused near the sea-shore. There are two observers, X under water and Y on land, each at a distance of 1 km from the point of explosion
    (a) X will hear the sound earlier
    (b) Y will hear the sound earlier
    (c) Both will hear the sound at the same time.
    (d) Y will not hear the sound at all
11. In a long spring which of the following type of waves can be generated
    (a) longitudinal only
    (b) transverse only
    (c) both longitudinal and transverse
    (d) electromagnetic only

12. When a vibrating object moves forward, it pushes and compresses the air in front of it creating a region of high pressure called
(a) rarefaction (b) compression
(c) depression (d) hypertension

13. Human ears can sense sound waves travelling in air having wavelength of
(a) 10^{-3} m (b) 10^{-2} m (c) 1 m (d) 10^{2} m

14. Which of the following statements is wrong?
(a) Sound travels in straight line
(b) Sound is form of energy
(c) Sound travels in the form of waves
(d) Sound travels faster in vacuum than in air

15. Voice of a friend is recognised by its
(a) pitch (b) quality
(c) intensity (d) velocity

16. When the vibrating object moves backwards, it create a region of low pressure called
(a) rarefaction (b) compression
(c) depression (d) hypertension

17. A sound wave travels from east to west in which direction do the particles of air move ?
(a) East-west (b) North-south
(c) Up and down (d) None of these

18. The unit of quantity on which loudness of sound depends is
(a) metre (b) Hz
(c) metre/second (d) second

19. The frequency of a wave travelling at a speed of 500 ms^{-1} is 25Hz. Its time period is
(a) 20 s (b) 0.05 s
(c) 25 s (d) 0.04 s

20. Pressure in the compression or rarefaction is related to the
(a) Number of particles of the medium in a given volume
(b) Density of particles in the medium
(c) Position of the particles
(d) Both (a) and (b)

21. Compression is a region of
(a) low pressure (b) normal pressure
(c) high pressure (d) no pressure

22. During summer, an echo is heard:
(a) sooner than during winter
(b) later than during winter
(c) after same time as in winter
(d) None of these

23. Echo is a type of
(a) reflected sound (b) refracted sound
(c) polarised sound (d) None of these

24. Sound is a
(a) mechanical wave
(b) electro-magnetic wave
(c) longitudinal waves
(d) Both (a) and (c)

25. Sitar is a
(a) wind instrument (b) stringed instrument
(c) percussion instrument (d) reed instrument

26. Sound cannot travel though –
(a) solids (b) liquids (c) gases (d) vacuum

27. To hear a distinct echo, the minimum distance of a reflecting surface should be :
(a) 17 metres (b) 34 metres
(c) 68 metres (d) 340 metres

28. Sound can be characterized by its
(a) frequency only
(b) amplitude only
(c) speed only
(d) frequency, amplitude and speed

29. Which one of the following materials will reflect sound better?
(a) Thermocole
(b) Curtain made from cloth
(c) Steel
(d) Paper

30. A wave of frequency 1000 Hz travels between X and Y, a distance of 600 m in 2 sec. How many wavelengths are there in distance XY –
(a) 3.3 (b) 300 (c) 180 (d) 2000

31. The material used for making the seats in an auditorium has sound absorbing properties. Why?
(a) It reduces reverberations.
(b) It makes the quality of sound better
(c) It makes the sound travel faster
(d) All of the above

32. Select the irrelevant statement
(a) Compressions are the regions where particles are crowded together
(b) Compressions are represented by the upper portion of the curve in density-distance graph
(c) Rarefactions are where particles are spread apart
(d) Valleys are represented by the straight line

33. Bats can hunt at night
(a) their eyesight is good
(b) they can smell their prey
(c) the high-pitched ultrasonic squeaks of the bat are reflected from the obstacles or prey and returned to bat's ear and thus the bat is able to detect.
(d) All of the above

34. Which of the following statements is/are correct about sound?
(i) Sound is produced by a vibrating body.
(ii) Sound needs a medium for propagation.
(iii) If 2 sounds are equally loud, then their pitch will also be equal.
(a) (i) & (iii) (b) only (iii)
(c) (i), (ii) & (iii) (d) (i) & (ii)

35. Which of the following are true about speed of sound?
(i) Sound propagates through a medium at a finite speed.
(ii) The speed of sound decreases when we go from solid to gaseous state
(iii) Speed of sound increases with increase in temp
(a) only (i) (b) (i) & (iii)
(c) (i), (ii) & (iii) (d) (i) & (ii)

36. Select the odd one out
(a) S.I. Unit is hertz (Hz)
(b) Frequency = 1 / Time Period
(c) Objects vibrating at different frequencies produce same pitch
(d) Higher the frequency, higher is the pitch

37. Identify the sound wave with low frequency/low pitch.
(a)  (b) 
(c) Both (a) & (b) (d) None of the above