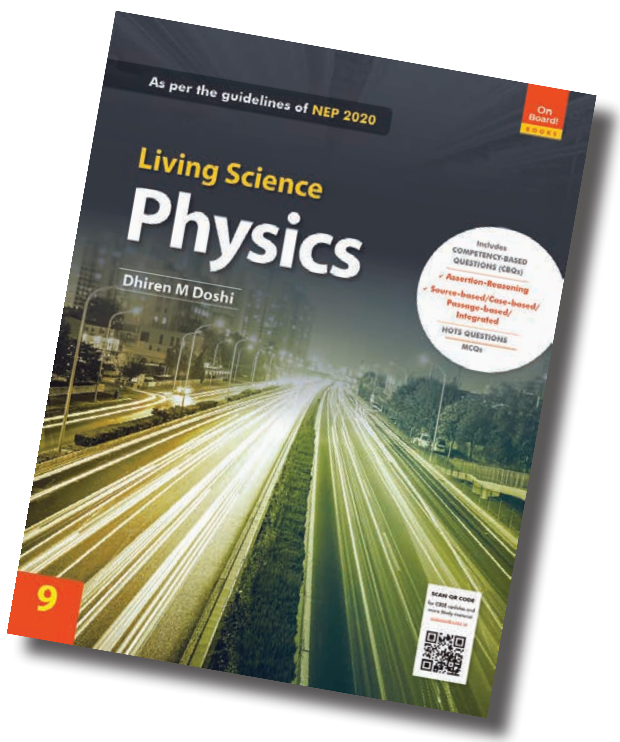
CBSE Living Science

PHYSICS

Book 9

TEACHER'S HANDBOOK



On Board! BOOKS

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CHAPTER – 1

MOTION

P. 11-12 Check Your Progress 1

A. Multiple-Choice Questions

1. **b**. motion
2. **b**. metre
3. **d**. zero
4. **a**. positive
5. **b**. length

B. Very Short Answer Type Questions

1. **a**. Temperature. The other terms are concerned with mechanics.
   b. Weight. The other terms are concerned with motion.
   c. Big table. The other objects are in motion whereas table is at rest.
2. A book lying on the table is an object at rest. Its position does not change with the passage of time.
3. Two examples where we feel the motion through indirect evidences are motion of air by observation of movement of dust and movement of leaves and branches.
4. Rest and motion are relative terms. This can be exemplified with a train journey. A body is said to be in motion if it changes its position with respect to a fixed point taken as a reference point in its surroundings with the passage of time. Sitting in moving train, we are in motion with respect to a farmer working outside or the railway platform but when we compare our position with respect to objects in the train like, fan, light, etc. we are at rest. Hence, motion and rest are relative terms.
5. **Scalar quantities:** length, distance, power, time, energy, mass.
   Vector quantities: velocity, acceleration, momentum, weight, displacement, force.
6. A bird flying in the sky is an object in random motion.
7. **a**. Car moving on a straight road
   b. Javelin thrown by an athlete
   c. Pendulum of a clock
   d. Plucked string of a sitar
   e. Tyres of a car moving on straight road – they exhibit both rotatory as well as rectilinear motion.

C. Short Answer Type-I Questions

1. A man walking on the road is said to be in a state of motion because, with the passage of time, he changes his position with respect to the trees or buildings (taken as a reference point) in the surroundings.
2. A body is said to be at rest if it does not change its position with respect to a fixed point taken as reference point in its surroundings with the passage of time. On the other hand, a body is said to be in motion if it changes its position with respect to a fixed point taken as a reference point in its surroundings with the passage of time.
3. Mass is a physical quantity which is completely described by its magnitude. Hence, it is a scalar quantity.
4. Since after completing one revolution around the sun, the earth comes back to the starting point, so its displacement is zero.
5. The distance covered will be twice the circumference of the track, i.e. $2 \times 2 \times \pi r = 4\,\pi r$. Since the distance between the initial and final positions of the athlete is zero, the displacement is zero.
6. When the earth completes one complete rotation about its axis, the displacement of a fixed point on it is zero.

D. Short Answer Type-II Questions

1. **a**. A physical quantity which is described completely by its magnitude is called a scalar quantity. Examples are mass and length.
   A physical quantity which is described completely by its magnitude as well as direction is called a vector quantity. Examples are force, weight and momentum.

   b.

Parameter	Distance	Displacement
1. Definition	The actual length of the path travelled by a moving body irrespective of the direction is called the distance travelled by the body.	The shortest distance measured between the initial and the final positions of a moving body in a particular direction is called its displacement.
2. Physical quantity	Scalar	Vector

3. Value	It is always positive. It can never be zero or negative.	It may be positive, negative or zero.
4. Dependence on path	It depends on the path followed by the moving object.	It does not depend on the path followed by the moving object.
5. Magnitude	Its magnitude is always greater than or equal to displacement.	Its magnitude is always less than or equal to distance travelled.

2. a. The distance travelled by the athlete is 100 m.

b. Since the track is straight or the initial and final positions of the athlete will not be the same. Hence, the displacement is also 100 m.

3. Let us assume the rectangular track to be represented by ABCD. A man starts at A and reaches C as per the question. Since the length (AB) is 40 m and width (BC) is 30 m, the total distance travelled by the man becomes

AB + BC = 40 m + 30 m = 70 m.

The displacement can be represented by AC.

Using Pythagorean theorem,

$AC = \sqrt{AB^2 + BC^2}$

$AC = \sqrt{(40)^2 + (30)^2}$

AC = 50 m

Therefore, the displacement is 50 m.

4. Let us assume the square field to be represented by ABCD. A persons starts at A and his maximum displacement will be when he reaches C. Since the length of the square is 100 m, both AB and BC are 100 m. To calculate maximum displacement, AC, apply Pythagorean theorem

$AC = \sqrt{AB^2 + BC^2}$

$AC = \sqrt{(100)^2 + (100)^2}$

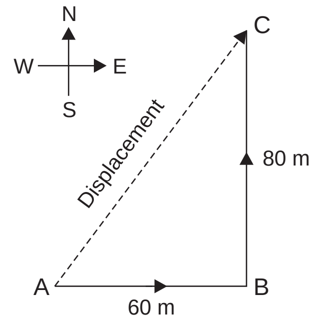
$AC = 100\sqrt{2}$ m

5. Let the figure represent the path followed by the object. The object first moves 60 m due east and then 80 m due north. Hence, the total distance travelled is 60 m + 80 m = 140 m. The displacement can be calculated using Pythagorean theorem as,

$AC = \sqrt{AB^2 + BC^2}$

$AC = \sqrt{(60)^2 + (80)^2}$

AC = 100 m due north-east.



6. When the batsman got run out he had completed one run and was at the mid point of pitch. Hence, the total distance travelled by him becomes 18 m + 9 m (half of 18) = 27 m. Since, he was half the distance away from his initial position, his displacement becomes 9 m.

P. 19-20 CHECK YOUR PROGRESS 2

A. Multiple-Choice Questions

1. **c**. equal distances in equal intervals of time
2. **c**. straight line sloping upwards
3. Speed of the car = 30 km/h

   Time = 15 minutes, i.e. $\frac{1}{4}$ h

   Distance = Speed × Time

   $= 30 \times \frac{1}{4} = 7.5$ km

   Therefore, the answer is **b**.
4. **d**. either more than or equal to one.
5. **d**. all a. b. and c.

B. Very Short Answer Type Questions

1. A body is said to have uniform motion, if it travels equal distances in equal intervals of time, no matter how small these intervals may be. Two examples of uniform motion could be the movement of hands of watches and the movement of the earth around the sun.
2. A body is said to be in non-uniform motion if it covers unequal distances in equal intervals of time, however, small these time intervals may be. Two examples are (i) a free-falling stone under the action of gravity, (ii) when brakes are applied to a speeding car.
3. A graph of distance versus time for an object in uniform motion will be a straight line.
4. A graph of distance versus time for an object in non-uniform motion will be a curved line.

5. **a.** Non-uniform motion
   b. Uniform
   c. Uniform
   d. Non-uniform.
6. The average speed of a moving body is the total distance travelled by the body divided by the total time taken to cover this distance. Its SI unit is m/s.
7. The speed of a body is the distance travelled by it per unit time. A speedometer is installed in automobiles to measure instantaneous speed.
8. Velocity can be defined as the distance travelled by a body in per unit time in a definite direction. The SI unit of velocity is m/s.
9. Velocity is a physical quantity which is described both by magnitude and direction. Hence, it is a vector quantity.
10. When a body is travelling with a constant speed in a particular direction, then the magnitude of both speed and velocity will be equal.
11. A body is said to have uniform velocity if it covers equal distances in equal intervals of time, in a particular direction, however, small these time intervals may be.

    A body is said to have variable velocity if it covers unequal distances in equal intervals of time, in a particular direction, however, small these time intervals may be or if it covers equal distances in equal intervals of time but its direction keeps on changing.
12. An artificial satellite revolving around the earth at a constant speed moves in a circular path and hence keeps changing the direction constantly. Therefore, it cannot have uniform velocity.
13. **a.** Distance = 200 m

    Time taken to cover the distance = 4 s

    $$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{200}{4} = 50 \text{ m/s}$$

    b. Speed from the previous calculation = 50 m/s

    Distance = 300 m

    $$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{300}{50} = 6 \text{ s}$$

    c. Speed = 50 m/s

    Time = 5 s

    Distance = 50 × 5 = 250 m
14. Let the distance be *s*.

    $$\text{Speed} = 50 \text{ km/h}$$

    $$\text{Time taken} = \frac{s}{50} \text{ h}$$

    $$\text{In the second case time} = \frac{s}{40}$$

    Average speed = Total distance/Total time

    $$\text{Total distance} = s + s = 2s$$

    $$\text{Total time} = \frac{s}{50} + \frac{s}{40} = \frac{90s}{200}$$

    $$\text{Average speed} = \frac{2s}{\frac{90s}{200}} = 44.4 \text{ km/h}$$
15. Length of the swimming pool = 90 m

    As per the question, Sweta swims a total distance of 180 m (90 + 90). Total time taken by Sweta to swim = 90 seconds. Average speed = total distance/total speed = $\frac{180}{90}$ = 2 m/s. Since, Sweta comes back to the initial point, total displacement is zero. Average velocity = total displacement/total time = $\frac{0}{90}$ = 0.

C. Short Answer Type-I Questions

1. Speed of a body is the distance travelled per unit time. The SI unit of speed is m/s.
2. Speed is a physical quantity describes by the magnitude. It is the distance travelled per unit time irrespective of the direction. Hence, it is a scalar quantity.
3. To know the exact position of a moving body we must know the distance travelled by the body in the given interval of time and the direction in which the body is moving.
4. If a body moves along a straight line in a negative direction, the velocity will be negative.
5. Time taken for the travel = 3 hours 15 minutes = $\frac{13}{4}$ hours $\left(3+\frac{1}{4}\right)$, speed = 60 km/h, Distance = speed × time = 60 × $\frac{13}{4}$ = 195 km.

D. Short Answer Type-II Questions

1. **a.** Speed of a body is the distance travelled per unit time whereas velocity is distance travelled per unit time in a definite direction.

   b. An odometer is a device that measures the distance travelled by a vehicle in kilometres. A speedometer is a device that measures the speed of a vehicle at a particular instant of time.

2. a. Distance between the two stations = 200 km. Hence, total distance travelled by the train

$$= 200 + 200 = 400 \text{ km}.$$

Time taken to travel from station A to B = 2 h
Time taken to travel from station B to A = 3 h
Total time taken for the travel = 5 h
Average speed = Total distance/Total time

$$= \frac{400}{5} = 80 \text{ km/h}$$

b. The train starts from station A and finally comes back to station A. Hence, the total displacement is 0.

Average velocity

= Total displacement/Total time

$= \frac{0}{5} = 0.$

3. Distance = 1.5 km = 1500 m

Time taken = 150 s

Speed = $\frac{1500}{150}$ = 10 m/s

The velocity is 10 m/s due east.

4. Odometer is the device that reads the distance travelled by a vehicle.

The initial reading is 4000 km
Final reading = 4600
Distance travelled = 4600 – 4000 = 600 km
Time taken for the trip = 10 h

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

$$= \frac{600}{6} = 60 \text{ km/h}$$

To convert it into m/s, $60 \times \frac{1000}{3600}$ = 16.6 m/s.

5. Speed of the signal = 3×10^8 m/s

$$= 3 \times 10^8 \times \frac{3600}{1000} \text{ km/h}$$

Time taken = 6 minutes = 0.1 h

Distance = Speed × Time

$$= 3 \times 10^8 \times \frac{3600}{1000} \times 0.1$$

$$= 1.08 \times 10^8 \text{ km}$$

P. 25 Check Your Progress 3

A. Multiple-Choice Questions

1. **c.** m/s^2
2. **b.** $v > u$
3. **c.** zero
4. **b.** $v = 0$
5. **a.** negative

B. Very Short Answer Type Questions

1. Acceleration
2. The rate of change of velocity of a body with respect to time is called its acceleration.
3. The SI unit of acceleration is m/s^2.
4. **a.** A body falling towards earth.
   b. A ball thrown vertically up.
   c. A body falling freely under gravity.
   d. A car driven on the road with frequent application of brakes.
   e. A train travelling from one station to the next.

C. Short Answer Type-I Questions

1. Velocity can be changed by changing the speed but keeping its direction same, keeping the speed constant and changing the direction of motion and by changing the speed as well as direction of motion.

2. Initial velocity u = 0 km/h = 0 m/s

Final velocity v = 54 km/h

$$= \frac{54 \times 1000}{60 \times 60} \text{ m/s} = 15 \text{ m/s}$$

Time = 15 s

$$\text{Acceleration} = \frac{v - u}{t} = \frac{15 - 0}{15} = 1 \text{ m/s}^2$$

3. Initial velocity u = 18 km/h

$$= \frac{18 \times 1000}{60 \times 60} \text{ m/s} = 5 \text{ m/s}$$

Final velocity v = 36 km/h

$$= \frac{30 \times 1000}{60 \times 60} \text{ m/s} = 10 \text{ m/s}$$

Time = 5 s

$$\text{Acceleration } a = \frac{v - u}{t} = \frac{10 - 5}{5} = 1 \text{ m/s}^2$$

D. Short Answer Type-II Questions

1. a. Differences between velocity and acceleration

S.no	Parameter	Velocity	Acceleration
1.	Definition	The velocity of a body is the distance travelled by it per unit time in a definite direction.	The rate of change of velocity of a body with respect to time is called acceleration.
2.	Formula	Velocity = displacement/ time	Acceleration = change in velocity/ time taken to change
3.	Zero value	When the body is not moving its velocity is zero.	When the body is moving with a constant velocity, its acceleration is zero.

4.	Direction of motion	Velocity decides the direction of motion since the direction of velocity is always in the direction of motion of the body. For example, when a ball is thrown vertically upwards, then the direction of motion of the ball and the velocity is the same, i.e. upward.	Acceleration does not decide the direction of motion since the direction of acceleration may or may not be in the direction of the motion of the body. For example, when a ball is thrown vertically upwards then the direction of motion of the ball is upwards but acceleration due to gravity acts downwards towards the earth. Thus, the direction of acceleration is opposite to the direction of motion of the ball.
5.	SI units	m/s	m/s^2

b. Differences between acceleration and retardation

S.no	Parameter	Acceleration	Retardation
1.	Definition	If the velocity of a body increases, then the rate of change of velocity is positive and is called acceleration.	If the velocity of a body decreases, then the rate of change of velocity is negative and is called retardation.
2.	Example	A body falling freely from a certain height has a positive acceleration of 9.8 m/s^2	If a body is thrown in the upward direction, its velocity decreases at the rate of 9.8 m/s^2
3.	Relation	The final velocity is more than the initial velocity, i.e. $v > u$	The final velocity is more than the initial velocity, i.e. $v < u$

c. When a body travels in a straight line and its velocity changes by equal amounts in equal intervals of time, it is said to have uniform acceleration. When the velocity of a body changes by unequal amounts in equal intervals of time, it is said to have non-uniform acceleration.

2. In the first case, initial velocity u = 0 km/h = 0 m/s

Final velocity v = 5 m/s

Time = 25 s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{5-0}{25} = 0.2 \text{ m/s}^2$$

In the second case, Initial velocity u = 5 m/s

Final velocity v = 4 m/s

Time = 5 s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{4-5}{5} = -0.2 \text{ m/s}^2$$

P. 39-40 Check Your Progress 4

A. Multiple-Choice Questions

1. **c.** acceleration
2. **c.** at rest
3. **d.** curved line
4. **a.**
5. **c.**

B. Very Short Answer Type Questions

1. **a.** A body initially at rest and later moving with a uniform acceleration.

b. Body under uniform retardation.

c. Body moving with uniform velocity.

d. Body first moving with uniform acceleration, then with a constant velocity and then with uniform retardation.

e. Body moving with velocity increasing and decreasing in a stepwise manner.

f. Body moving with velocity increasing and decreasing non-uniformly.

g. Body initially not at rest moving with uniform acceleration.

h. Body whose velocity decreases non-uniformly.

2. **a.** Nature of motion and speed.

b. The nature of motion, acceleration and distance travelled by the body.

3. **a.** Initial velocity at A = 0 m/s

Final velocity at B = 25 m/s

Change in velocity = (25 – 0) = 25 m/s

Time taken = 3 s

Acceleration = Change in velocity/Time taken

$$= \frac{25}{3} = 8.3 \text{ m/s}^2$$

b. Initial velocity B, u = 25 m/s

Final velocity at C, v = 15 m/s

Change in velocity = $v - u$

= (15 – 25) = – 10 m/s

Time taken = 1 s

Retardation = $\frac{-10}{1}$ = 10 m/s^2

c. Distance covered in the region ABCD

AB = $\frac{1}{2}$ × Base × Height

= $\frac{1}{2}$ × 3 × 25 = 37.5 m

BC, $s = ut + \frac{1}{2}at^2$

= 25 × 1 + $\frac{1}{2}$ × (–10) × 1 × 1

= 25 – 5 = 5 m

CD = $\frac{1}{2}$ × Base × Height

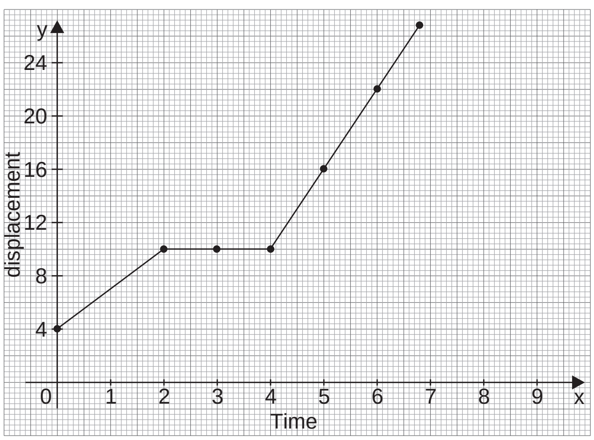
= $\frac{1}{2}$ × 2 × 15 = 15 m

Total distance = 37.5 m + 20 m + 15 m

= 72.5 m

d. Average velocity = $\frac{15}{2}$ (since the distance travelled in 2 s is 15 m) = 7.5 m/s

4.



Total displacement in the time interval of 1 to 5 s

= 16 – 6 = 10 m

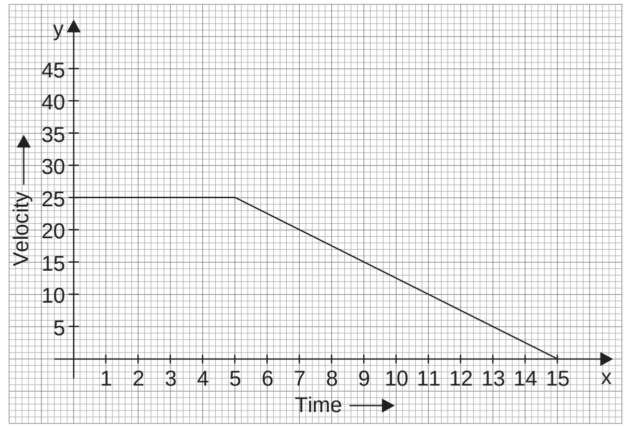
Total time = 5 – 1 = 4 s

Average velocity = $\frac{10}{4}$

= 2.5 m/s

C. Short Answer Type-I Questions

1.



a. Acceleration

$a = \frac{v-u}{t} = \frac{0-25}{10}$

= – 2.5 m/s^2

According to formula

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

$(0)^2 = (25)^2 + 2 \times (-2.5 \text{ m/s}^2) \times s$

625 = 5s

$s = \frac{625}{5}$ = 125 m

b. Retardation = 2.5 m/s^2

D. Short Answer Type-II Questions

1. a. Speed of the body as it moves from A to B:

Total distance covered/Total time = $\frac{6}{3}$ = 2 m/s

b. Speed of the body as it moves from B to C:

Distance covered = 0, hence, speed is 0

c. Speed of the body as it moves from C to D

= $\frac{2 \text{ m}}{2 \text{ s}}$ = 1 m/s

2. a. Velocity at point C is 40 km/h

b. Acceleration between A and B:

Initial velocity at A = 20 m/s

Final velocity at B = 40 m/s

Change in velocity = 40 – 20 = 20 km/h

Acceleration = Change in velocity/Time

= $\frac{20}{3}$ = 6.67 km/h^2

c. Acceleration between B and C = 0. Since the change in velocity is zero.

d. Acceleration between C and D:

Initial velocity at C = 40 km/h

Final velocity at B = 0 km/h

Change in velocity = 40 km/h

Time taken = 2 h

Change in velocity = Final velocity – Initial velocity

$= 0 - 40 = -40$ km/h

Acceleration = Change in velocity/Time

$$= \frac{-40 \text{ km}}{2 \text{ h}} = -20 \text{ km/h}^2$$

3. a. Acceleration of the body:

Initial velocity = 0 m/s

Final maximum velocity = 40 m/s

Time taken = 2 s

Change in velocity = Final velocity – Initial velocity

$= 40 - 0 = 40$ m/s

$$\text{Acceleration} = \frac{40 \text{ m}}{2 \text{ s}} = 20 \text{ m/s}^2$$

b. Retardation:

Initial velocity = 40 m/s

Final maximum velocity = 0 m/s

Time taken = 2 s

Change in velocity = Final velocity – Initial velocity

$= 0 - 40 = -40$ m/s

Acceleration = Change in velocity/Time

$$\text{Retardation} = -\frac{40}{2} = -20 \text{ m/s}^2$$

c. Distance covered by the body = Area under the graph

$$= \frac{1}{2} \times \text{Base} \times \text{Height}$$

$$= \frac{1}{2} \times 4 \times 40 = 80 \text{ m}$$

4. a. Distance travelled at the end of 2.5 s is 25 m.

b. The speed of the car = Total distance/Total time

$$= \frac{40 \text{ m}}{4 \text{ s}}$$

$= 10$ m/s

P. 45-46 Check Your Progress 5

A. Multiple-Choice Questions

1. b. $(v - u)/t$
2. a. $\sqrt{u^2 + 2as}$
3. c. $v = u + at$
4. a. 5 km/h^2
5. b. 10 m/s^2

B. Very Short Answer Type Questions

1. When a body having uniformly accelerated motion travels in a straight line, the relationship between its initial velocity(u), final velocity (v) and acceleration (a) during its motion, distance covered by it in a certain time are called equations of motion.
2. $v = u + at$
3. $s = ut + \frac{1}{2}at^2$
4. $v^2 = u^2 + 2as$
5. Zero
6. A body moving with a uniform velocity has zero acceleration.
7. a. A body initially at rest.
   b. When a moving body is stopped.
   c. A body moving with uniform velocity.
8. Zero
9. Initial velocity $u = 36$ km/h

$$= 36 \times \frac{1000}{3600} \text{ m/s} = 10 \text{ m/s}$$

Final velocity $v = 72$ km/h = 20 m/s

Time $t = 20$ s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{20-10}{20} = 0.5 \text{ m/s}^2$$

$$\text{Distance travelled } s = ut + \frac{1}{2}at^2$$

$$= 10 \times 20 + \frac{1}{2}(0.5) \times (20)^2$$

$= 300$ m

C. Short Answer Type-I Questions

1. a. $s = ut + \frac{1}{2}at^2$

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

2. Initial velocity $u = 6$ m/s

Acceleration = 1.5 m/s^2

Time = 5 s

Final velocity = ?

We know that $a = \frac{v-u}{t}$

Therefore, $1.5 \text{ m/s}^2 = \frac{v-6}{5}$

$1.5 \times 5 = v + 6$

$7.5 = v + 6$

$v = 7.5 + 6$

$= 13.5$ m/s

$$\text{Distance travelled } s = ut + \frac{1}{2}at^2$$

$$= 6 \times 5 + \frac{1}{2} \times 1.5 \times (5)^2$$

$= 48.75$ m

3. Consider a body having initial velocity u and moving with a uniform acceleration a. If after

time t, its velocity is v, then from the definition of acceleration, we get,

$$\text{Acceleration } a = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time}}$$

or $$a = \frac{v - u}{t}$$

$$v - u = at$$
$$v = u + at$$

4. Consider a body moving in a straight line and having initial velocity, u and uniform acceleration, a. If after time t, its velocity is v, then the distance travelled, s in this time is given by

$$s = \text{Average velocity} \times \text{Time}$$

But,

$$\text{Average velocity} = \frac{\text{Initial velocity} - \text{Final velocity}}{\text{Time}}$$
$$= \frac{u + v}{2}$$

Thus, we can write

$$s = \frac{u + v}{2} \times t \qquad \text{(i)}$$

We know $v = u + at$

or $$t = \frac{v - u}{a}$$

Substituting the value of t in equation (i), we get,

$$s = \left(\frac{u + v}{2}\right) \times \left(\frac{v - u}{a}\right)$$
$$= \frac{uv - u^2 + v^2 - uv}{2a}$$
$$= \frac{v^2 - u^2}{2a}$$
$$v^2 - u^2 = 2as$$

5. Consider a body having initial velocity u and moving with a uniform acceleration a. Let after time t, its velocity be v. For a body moving in a straight line under uniform acceleration, the distance travelled s in time t is given by

Distance travelled s = Average velocity × Time

But,

$$\text{Average velocity} = \frac{\text{Initial velocity} + \text{Final velocity}}{2}$$
$$= \frac{u + v}{2}$$

For a body under uniform acceleration, $v = u + at$. Therefore,

$$\text{Average velocity} = \frac{u + (u + at)}{2} \quad (v = u + at)$$
$$= \frac{2u + at}{2}$$
$$= u + \frac{1}{2}at$$

Distance travelled (s) = Average velocity × Time

$$= ut + \frac{1}{2}at \times t$$
$$= ut + \frac{1}{2}at^2$$

6. Initial velocity, u of the object = 0

(as before being dropped it was at rest)

Acceleration = 10 m/s^2

Time = 2 s

Applying the equation $v = u + at$

Velocity after 2 s = 0 + 10 × 2 = 20 m/s

Hence, the speed of the object after 2 s is 20 m/s.

7. Initial velocity = 0

Final velocity = ?

t = 5 s

a = 10 m/s^2

$$s = ut + \frac{1}{2}at^2$$
$$= 0 \times 5 + \frac{1}{2} \times 10 \times 5 \times 5$$
$$= 125 \text{ m}$$

Hence, distance travelled by the object is 125 m.

8. Initial velocity, u = 18 km/h

$$= \frac{18 \times 1000}{60 \times 60} \text{ m/s} = 5 \text{ m/s}$$

Final velocity, v = 54 km/h

$$= \frac{54 \times 1000}{60 \times 60} \text{ m/s} = 15 \text{ m/s}$$

Applying $v = u + at$

$$15 = 5 + a \times 5$$
$$10 = 5a$$
$$a = 2 \text{ m/s}^2$$

D. Short Answer Type-II Questions

1. Graphical derivation of $v = u + at$

Consider an object moving with a uniform velocity u in a straight line. Let it be given a uniform acceleration a at time $t = 0$, when its initial velocity is u. As a result of the acceleration, its velocity increases to v (final velocity) in time t and s is the distance covered by the object in time t.

The figure shows the velocity–time graph of the motion of the object.

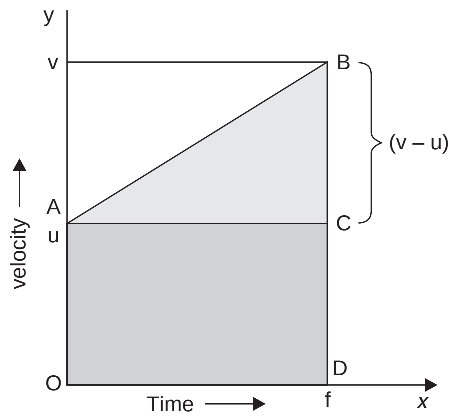
Slope of the v–t graph gives the acceleration of the moving object.

Thus, acceleration = Slope AB =

$$\frac{BC}{AC} = \frac{v - u}{t - 0}$$
$$a = \frac{v - u}{t}$$

or, $$v - u = at$$
$$v = u + at$$

2.



Graphical derivation of $s = ut + \frac{1}{2}at^2$

Distance travelled s = Area of the trapezium ABDO

= Area of rectangle ACDO + Area of ΔABC

$= OD \times OA + \frac{1}{2} BC \times AC$

$= t \times u \times \frac{1}{2}(v - u) \times t$

$= ut + \frac{1}{2}(v - u) \times t$

$= t \times u + \frac{1}{2}(v - u) \times t$

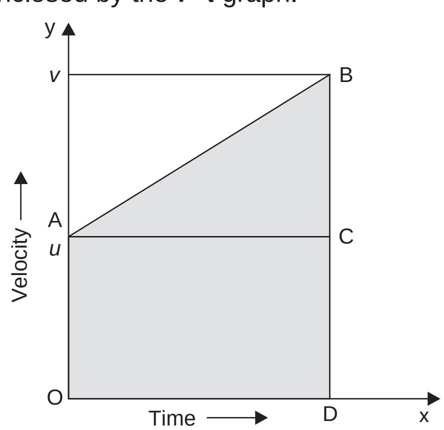
$= ut + \frac{1}{2}(v - u) \times t$

($v = u + at$; first eqn. of motion; $v - u = at$)

$= ut + \frac{1}{2}at \times t$

Therefore, $s = ut + \frac{1}{2}at^2$.

3. Let u be the initial velocity of an object and a be the acceleration produced in the body. The distance travelled s in time t is given by the area enclosed by the v–t graph.



Graphical derivation of third equation

s = Area of the trapezium OABD

$= \frac{1}{2}(b_1 + b_2)h$

$= \frac{1}{2}(OA + BD)AC$

$= \frac{1}{2}(u + v)t$ (i)

But we know that $a = \frac{v - u}{t}$

or $t = \frac{v - u}{a}$

Substituting the value of t in equation (i) we get,

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

$2as = (v + u)(v - u)$

$(v + u)(v - u) = 2as$

[using the identity $a^2 + b^2 = (a + b)(a - b)$]

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

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

4. Initial velocity, u = 0.5 m/s

Final velocity, v = 0

Retardation = – 0.05 m/s^2,

Applying the equation

$v = u + at$

$0 = 0.5 - 0.05 \times t$

$0.5 = 0.05\ t$

$t = \frac{0.5}{0.05} = 10$ s

Hence, it will take 10 s to stop.

5. Acceleration = 6 m/s^2

Time = 2 s

Final velocity = 0 (since the car stops or comes to rest after applying the brakes)

We know that

$v = u + at$

$0 = u + 6 \times 2$

$0 = u + 12$

$u = -12$ m/s

Now,

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

$= -12 \times 2 + \frac{1}{2} \times 6 \times (2)^2$

$= -24 + 12$

$= -12$

The displacement is 12 m in negative direction. Hence, the distance travelled is 12 m.

6. Distance s = 500 m

Time = t

$u = 0$

t = 10 s

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

$$500 = 0 \times 10 + \frac{1}{2} \times a \times 10 \times 10$$

$1000 = 100a$

$a = 10 \text{ m/s}^2$

Final velocity

$v = u + at$

$v = 0 + 10 \times 10$

$v = 100$ m/s

7. Initial velocity $= 60 \text{ km/h} = \frac{60 \times 1000}{60 \times 60}$ m/s

$= \frac{100}{6}$ m/s

Final velocity $= 45 \text{ km/h} = \frac{45 \times 1000}{60 \times 60}$ m/s

$= \frac{50}{4}$ m/s

Time = 10 s

Applying $v = u + at$

$$\frac{50}{4} = \frac{100}{6} + a \times 10$$

$$\frac{50}{4} - \frac{100}{6} = 10a$$

$$\frac{150 - 200}{12} = 10a$$

$$-\frac{4.16}{10} = a$$

$$a = -0.416 \text{ m/s}^2$$

$$\cong -0.42 \text{ m/s}^2$$

Therefore, retardation $\cong 0.42 \text{ m/s}^2$

8. Initial velocity, u = ?

Final velocity, $v = 0$

Retardation = 5 m/s^2

Therefore, acceleration, $a = +5 \text{ m/s}^2$

Time = 15 s

Applying $v = u + at$

$0 = u + (-5) \times 15$

$0 = u + 75$

$u = 0 + 75 = 75$ m/s

9. Initial velocity, $u = 50$ m/s

Final velocity, $v = 0$

Distance covered by the bullet, s = 10 cm = 0.1 m

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

$0 - 2500 = 2 \times a \times 0.1$

$$-\frac{2500}{0.2} = a$$

$-12500 \text{ m/s}^2 = a$

i.e -12.5 km/s^2

Retardation = 12.5 km/s^2

10. Initial velocity u = ?

Final velocity, $v = 0$ m/s

Retardation = 2 m/s^2,

Therefore, acceleration, $a = -2 \text{ m/s}^2$

Time = 20 s

Applying $v = u + at$

$0 = u + (-2 \times 20)$

$0 + 40 = u$

or $u = 40$ m/s

11. Initial velocity, $u = 0$ m/s (as it starts from rest)

Final velocity, v = ?

Acceleration, $a = 4 \text{ m/s}^2$

Time, $t = 10$ s

First we have to find the final velocity in order to find the distance covered.

Applying $v = u + at$

$v = 0 + 4 \times 10$

$= 40$ m/s

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

$(40 \times 40) - 0 = 2 \times 4 \times s$

$1600 = 8s$

$$s = \frac{1600}{8} = 200 \text{ m.}$$

P. 49-50 Check Your Progress 6

A. Multiple-Choice Questions

1. c. both magnitude and direction

2. b. tangential to the circular path

3. b. a cyclist moving on a circular track

4. d. in a circular path with uniform speed

5. a. $\frac{2\pi r}{t}$

B. Very Short Answer Type Questions

1. When a point object is moving on a circular path with any speed, the motion of the object is said to be circular motion. Two examples of circular motion are moon revolving around the earth and the planets revolving around the sun.

2. The direction of motion and thereby the velocity.

3. Moon revolving around the earth, artificial satellite moving around the earth and the planets revolving around the sun.

4. The velocity of an object moving in a circular path at a constant speed changes continuously because of continuous change in the direction. Hence, it has a non-uniform velocity.

5. Speed

6. When he runs at a constant speed.

7. Refer to answer 3.

C. **Short Answer Type-I Questions**

1. When a point object is moving on a circular path with a constant speed, the motion of the object is said to be a uniform circular motion. Two examples of circular motion are moon revolving around the earth and the planets revolving around the sun.
2. The direction of an object moving in a circular path is along the tangent to the circle at any given point. Consider the example of a stone tied to a string and made to swing so that it moves in a circular path. Now if the tied thread is released, the stone moves along a straight line that is tangent to the circle at that point of time.
3. By using the formula $\frac{2\pi r}{t}$. Since speed is distance covered in per unit time. For a body moving in circular path, distance is the circumference of the circle which is given by $2\pi r$.

D. **Short Answer Type-II Questions**

1. **a.** $\frac{2\pi r}{t}$

   b. $2 \times \frac{2\pi r}{t} = \frac{4\pi r}{t}$

   c. $n \times \frac{2\pi r}{t}$
2. Differences between uniform linear motion and uniform circular motion

Uniform linear motion	Uniform circular motion
The linear velocity remains constant with time.	The angular velocity remains constant with time.
The acceleration is zero.	The direction of motion changes with time and hence, the linear velocity is not constant. There is an acceleration.
The direction of motion remains fixed and the particle does not retrace its path.	The particle retraces its path again and again moving round a fixed point or axis.

3. It is both – uniform motion as well as accelerated. So long as he moves at constant speed, it is uniform circular motion and since at every point he has to change the direction, it is an accelerated motion. Every object in uniform circular motion is in accelerated motion.
4. By rotating his body and then releasing the disc, the athlete makes the disc move in a direction tangential to the circular path and hence in a straight line.

P. 51–52 Higher Order Thinking Skills (HOTS) Questions

A. **Multiple-Choice Questions**

1. **d.** equal or less than 1
2. **b.** uniform acceleration
3. **a.** in uniform motion
4. **c.** in accelerated motion
5. **a.** if the car is moving on straight road.

B. **Very Short Answer Type Questions**

1. A body at rest can have acceleration because acceleration is the rate of change of velocity. For example, an oscillating pendulum. When the bob is at extreme position, its velocity is 0, but it has maximum acceleration.
2. The distance and displacement will be same if an object moves along a straight line only in one direction.

C. **Short Answer Type-I Questions**

1. No, it is not possible to stop a fast moving automobile instantaneously because it tends to continue to be its state of motion.
2. A body with zero velocity cannot be accelerating. However, if either the initial or the final velocity is zero then the body can have acceleration. But an object at rest cannot have acceleration since acceleration is the rate of change of velocity.

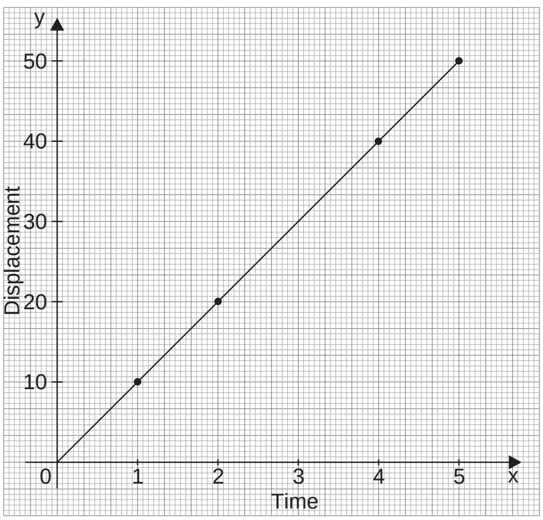
D. **Short Answer Type-II Questions**

1. A body travelling any distance but ultimately coming back to the starting point will have zero displacement. Consider two points A and B that are 5 km apart. Let us assume, a boy walks from A to B and then back form B to A. Now the total distance covered by the boy becomes (5 km + 5 km) 10 km. But the displacement is zero since he comes back to the starting point. Displacement is the shortest distance measured between initial and final points.
2. As per the question, the boy is moving along a circular path. So the circumference of the circle will give the total distance of the path. Circumference of a circle is given by $2\pi R$. Since he has completed only half revolution, the distance covered will also be half. Hence,

distance covered = $\frac{2\pi R}{2}$, i.e. πR. Now the displacement is the shortest distance between the initial and final points. A line passing through the centre of the circle represents the displacement of the boy. That implies the diameter of the circle gives the displacement. Since the radius is R, diameter will be $2R$. Hence, the displacement of the boy is $2R$.

3. A moving body having certain speed can have zero velocity. Let us consider the case of a boy travelling between two points A and B that are 10 m apart. If the boy travels from A to B in 5 s and back from B to A also in 5 s. Then his speed will be given by total distance/total speed $= \frac{20}{10}$ = 2 m/s. Now the velocity is given by total displacement/total time. The total displacement is zero as he comes back to the starting point. Hence, the velocity is also zero.

4.



a. Distance = 25 m

b. Speed = $\frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{40\text{ m}}{4\text{ s}} = 10\text{ m/s}$$

5. In the first case

Initial velocity, $u = 0$

(since Leena starts form rest)

Final velocity = 6 m/s

Time taken = 30 s

Applying $v = u + at$

$$6 = 0 + a \times 30$$
$$6 = 30a$$
$$a = \frac{6}{30} = 0.2\text{ m/s}^2$$

In the second case, the initial velocity u must be taken as 6 m/s, the final velocity v = 4 m/s and time = 5 s.

Applying $v = u + at$

$$4 = 6 + a \times 5$$
$$4 - 6 = 5a$$
$$-2 = 5a$$
$$a = -2/5 = -0.4\text{ m/s}^2$$

We know that negative acceleration is retardation. Retardation in this case is 0.4 m/s^2

P. 53–56 Exercises

A. Objective Type Questions

I. Multiple-Choice Questions

1. **a.**
2. **c.** It can be less than 480 km.
3. **c.** RS
4. **b.** $u^2/2g$
5. **a.** 4 m/s^2

II. Fill in the blanks

1. displacement
2. oscillatory
3. zero
4. non-uniform
5. velocity–time

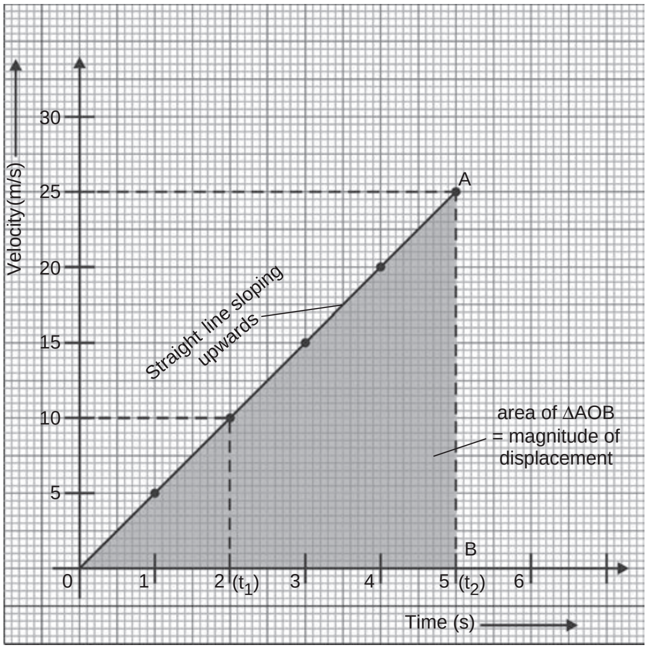
III. Assertion-Reasoning Type Questions

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

IV. Very Short Answer Type Questions

1. The magnitude of average velocity and average speed will be same when distance and displacement are same.
2. An object whose distance-time graph is a straight line parallel to time axis is an object at rest as its position does not change with time.
3. Area under the velocity time-graph gives the distance covered by the body at a particular interval of time.
4. **a.** Velocity **b.** Speed.
5. Tangent to the circle at that point.
6. Zero
7. Change in velocity by unequal amount in equal intervals of time.

8.



9. **b.** Displacement and **c.** Acceleration

10. Distance

11. Complete revolution

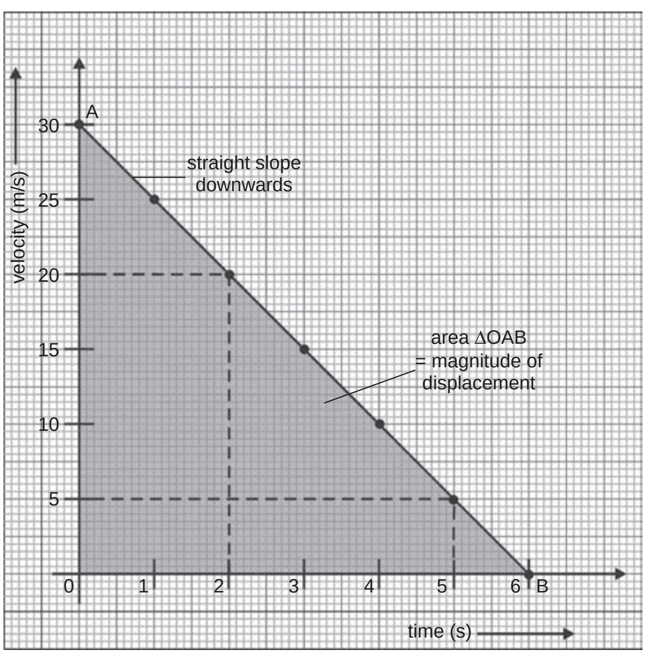
12. Distance travelled by an automobile

13. Variable motion

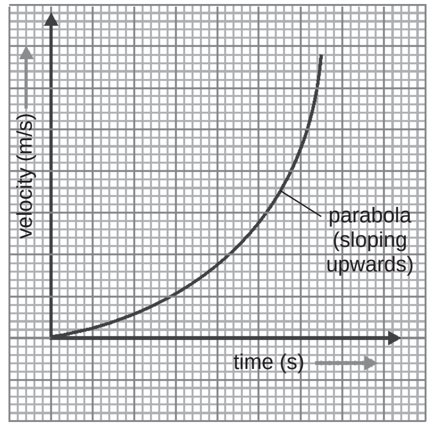
B. Short Answer Type-I Questions

1. Yes, the motion is accelerated because the satellite moves in a circular path and hence, keeps changing its direction constantly. Thereby the velocity changes and hence the acceleration.

2. **a.** Graph for uniform retardation:



b. Graph for non-uniform acceleration:

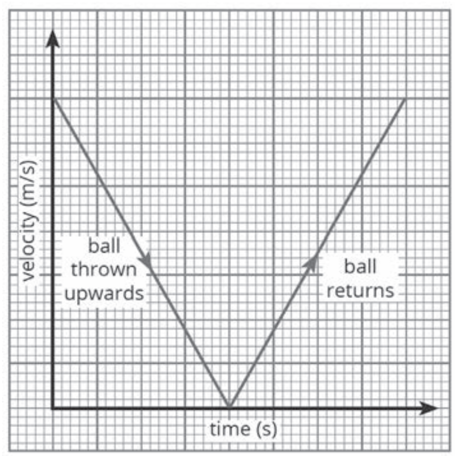


3. For a body which has moved through a semicircle of radius r,

   a. the distance travelled will be $\frac{1}{2}$ of the circumference. That is $\frac{2\pi r}{2} = \pi r$

   b. displacement = the diameter of the circle = $2r$

4.



5. Yes, velocity can change when acceleration is constant. Constant acceleration means the rate of change of velocity is uniform, that does not mean the velocity is constant.

C. Short Answer Type-II Questions

1. **a.** An oscillating pendulum. At the extreme position, the bob has zero velocity but maximum acceleration.

   b. Yes. A projectile.

   c. Not possible. A body moving with uniform velocity has zero acceleration.

2. The rate of change of velocity of a body with respect to time is called its acceleration.

   When the velocity of a body increases with time, its acceleration is positive. On the other hand, when the velocity of a body decreases with time, its acceleration is negative. The SI unit of acceleration is metre per second square (m/s^2).

D. Long Answer Type Questions

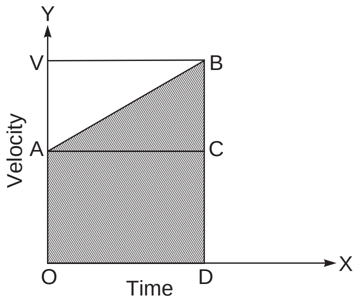
1. Graphical derivation of three equations of motion:

For first and second equation of motion, see pages 9 and 10, Short Answer Type-II Questions, Answer 1 and 2.

Third Equation of Motion

Let 'u' be the initial velocity of an object and 'a' be the acceleration produced in the body. The distance travelled 's' in time 't' is given by the area enclosed by the v–t graph.

Graphical Derivation of Third Equation



s = Area of the trapezium OABD.

$= \frac{1}{2}(b_1 + b_2)h$

$= \frac{1}{2}$ (OA + BC)AC

$= \frac{1}{2}(u + v)t$ (i)

But we know that $a = \frac{v - u}{t}$

or, $t = \frac{v - u}{a}$

Substituting the value of t in equation (i) we get,

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

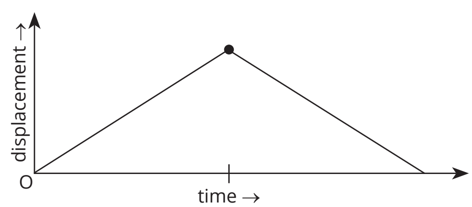
$2as = (v + u)(v - u)$

$(v + u)(v - u) = 2as$

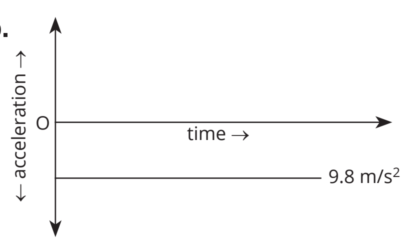
[using the identity $a^2 + b^2 = (a + b)(a - b)$]

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

2. a.



b.



E. Numerical Problems

1. Initial velocity, $u = 0$

Final velocity, v = 36 km/h

$= \frac{36 \times 1000}{60 \times 60}$ m/s = 10 m/s

Time = 12 min = 720 s

Applying $v = u + at$

$10 = 0 + a \times 720$

$a = \frac{1}{72}$

Substituting the value of a in $s = ut + \frac{1}{2}at^2$

Distance $s = 0 + \frac{1}{2} \times \frac{1}{72} \times 720$

= 3600 m = 3.6 km

2. Initial velocity, u = 40 km/h

$= \frac{40 \times 1000}{60 \times 60}$ m/s $= \frac{100}{9}$ m/s

Final velocity, v = 58 km/h

$= \frac{58 \times 1000}{60 \times 60}$ m/s $= \frac{145}{9}$ m/s

Time = 1 s

Applying $v = u + at$

$\frac{145}{9} = \frac{100}{9} + a \times 1$

$a = \frac{145}{9} - \frac{100}{9} = \frac{45}{9} = 5$ m/s^2

3. Initial velocity, u = 18 km/h

$= \frac{18 \times 1000}{60 \times 60}$ m/s = 5 m/s

Final velocity, v = 36 km/h

$= \frac{36 \times 1000}{60 \times 60}$ m/s = 10 m/s

Time = 5 s

Applying $v = u + at$

$10 = 5 + a \times 5$

$a = 1$ m/s^2

4. Initial velocity, u = 0 m/s

Final velocity, v = 20 m/s

t = 10 s

a = ?

Applying $a = \frac{v - u}{t}$

$= \frac{20 - 0}{10}$

$= \frac{20}{10} = 2$ m/s^2

5. Initial velocity, $u = 0$

Final velocity $= \frac{36 \times 1000}{60 \times 60}$ m/s = 10 m/s

Time = 10 s

Applying $v = u + at$

$$10 = 0 + a \times 10$$

$$a = 1 \text{ m/s}^2$$

6. **a.** Initial velocity, u = 90 km/h

$$= \frac{90 \times 1000}{60 \times 60} \text{ m/s} = 25 \text{ m/s}$$

Final velocity = $\frac{54 \times 1000}{60 \times 60}$ m/s = 15 m/s

Distance, s = 20 m

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

$$(15)^2 - (25)^2 = 2a \times 20$$

$$225 - 625 = 40a$$

$$-400 = 40a$$

$$a = -10 \text{ m/s}^2$$

Hence, the retardation is 10 m/s^2.

b. To calculate time for which the brakes are applied, we apply

$$v = u + at$$

$$15 = 25 + (-10) \times t$$

$$15 = 15t$$

$$t = 1 \text{ s}$$

7. **a.** Initial velocity = 18 km/h

$$= \frac{18 \times 1000}{60 \times 60} \text{ m/s} = 5 \text{ m/s}$$

Acceleration = 5 m/s^2

Time = 5 s

To calculate the distance,

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

$$= 5 \times 5 + \frac{1}{2} \times 5 \times (5)^2$$

$$= 87.5 \text{ m}$$

b. To calculate final velocity v, we apply

$$v = u + at$$

$$= 5 + 5 \times 5 = 30 \text{ m/s}$$

8. Initial velocity of the train = 30 m/s

Final velocity = 0

Acceleration = –1.5 m/s^2

Time taken to come to rest, t = 0

$$v = u + at$$

$$0 = 30 + (-1.5) \times t$$

$$0 = 30 - 1.5t$$

$$30 = 1.5t$$

$$t = \frac{30}{1.5} = 20 \text{ s}$$

9. **a.** Initial velocity, u = 18 km/h

$$= \frac{18 \times 1000}{60 \times 60} \text{ m/s} = 5 \text{ m/s}$$

Final velocity, v = 36 km/h

$$= \frac{36 \times 1000}{60 \times 60} \text{ m/s} = 10 \text{ m/s}$$

Time = 2 s

To calculate acceleration we apply

$$v = u + at$$

$$10 = 5 + a \times 2$$

$$a = 2.5 \text{ m/s}^2$$

b. To calculate the distance covered, we apply

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

$$= 5 \times 2 + \frac{1}{2} (2.5) \times (2)^2$$

$$= 15 \text{ m}$$

10. Initial velocity u of the car = 54 km/h = 15 m/s

Final velocity v = 72 km/h = 20 m/s

Time taken = 5 s

$$v = u + at$$

$$20 = 15 + a \times 5$$

$$a = -1 \text{ m/s}^2$$

11. Initial velocity u of the car = 0

Acceleration = 5 m/s^2

Time taken = 20 s

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

$$= 0 \times 20 + \frac{1}{2} \times 5 \times (20)^2$$

$$= 1000 \text{ m} = 1 \text{ km}$$

12. Initial velocity, u of the car = 27 m/s

Final velocity, v = 0 m/s

Acceleration = – 0.9 m/s^2

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

$$0 - (27)^2 = 2 \times (-0.9) \times s$$

$$-729 = -1.8\, s$$

$$s = 405 \text{ m}$$

13. Let the initial velocity be u.

Final velocity = 0

Acceleration = – 2.5 m/s^2

(since retardation is 2.5 m/s^2)

Time taken to stop = 10 s

Applying $v = u + at$

$$0 = u + (-2.5) \times 10$$

$$0 = u - 25$$

$$u = 25 \text{ m/s}$$

14. Distance covered = 500 m

Initial velocity, $u = 0$

Time taken = 10 s

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

$$500 = 0 \times t + \frac{1}{2} \times a \times (10)^2$$

$$a = 10 \text{ m/s}^2$$

To find the take off velocity, we apply

$$v = u + at$$

$$v = 0 + 10 \times 10 = 100 \text{ m/s}$$

15. Initial velocity of the bullet = 50 m/s

Final velocity of the bullet = 0

Distance travelled by the bullet = 10 cm = 0.1 m

To calculate acceleration, we apply

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

$$0 - (50)^2 = 2 \times a \times 0.1$$

$$a = -12500 \text{ m/s}^2 = -12.5 \text{ km/s}^2$$

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. **a.** ii **b.** iv **c.** iv **d.** ii **e.** ii

2. **a.** i **b.** iii **c.** i **d.** iv **e.** iii

G. Value-Based Questions (Optional)

1. **a.** The velocity of the ball decreases when it is thrown vertically upwards.

b. Togetherness, friendship, etc.

2. **a.** See page 12, Short Answer Type–I Questions, Answer 2.

b. Care for others, alertness, etc.

3. **a.** 100 km/h

b. Not following the speed limit.

CHAPTER – 2

FORCE AND LAWS OF MOTION

P. 62 Check Your Progress 1

A. Multiple-choice Questions

1. **c**. dynamics
2. **b**. Newton
3. **a**. balanced
4. **b**. vector quantity
5. **d**. F_1 has to be greater than F_2

B. Very Short Answer Type Questions

1. The study of causes of motion or changes in motion is called dynamics.
2. The effort needed to push or pull or change the shape of a body is known as force.
3. Effects of force are:
   - Force can cause motion in a stationary body.
   - Force can stop a moving body.
   - Force can change the direction of motion of a body.
   - Force can change the speed of a moving body.
   - Force can change the shape and size of a body.
4. **a.** • A book placed on the table can be moved by pushing.
   • A football can be set into motion by kicking.

   b. • Pushing a moving swing will make it faster.
   • Upon increasing the force on pedals, a cyclist can move faster.

   c. • A moving ball can be stopped by the force of our hand.
   • A rotating top can be stopped by the force exerted by our hands.

   d. • When a batsman hits the ball with his bat, the direction of the moving ball changes.
   • When a footballer kicks the rolling balls, its direction changes.

   e. • On stretching a spring its length increases.
   • On compressing a ball of plasticine, its shape changes.

C. Short Answer Type-I Questions

1. When a number of forces acting simultaneously on a body do not bring about any change in its state of rest or of uniform motion in a straight line then the forces acting on the body are said to be balanced forces.

   Example 1. A boy holding a school bag. The downward force due to the weight of the school bag is balanced by the force of pull applied by the hand I the upward direction by the boy.

   Example 2. A boy trying to push a heavy box along a rough surface. The pushing force applied by the boy is balanced by the large friction opposing the motion of the box.
2. When a number of forces acting simultaneously on a body bring about a change in its state of rest or of uniform motion in a straight line then the forces acting on the body are said to be unbalanced forces.

Example 1. Application of two unequal forces on an object will make it move in the direction decided by the greater force.

Example 2. When we stop pedalling the bicycle it slows down because frictional force becomes greater than applied force.

3. **a.** Push — iv. opening a door to get into a room

   b. Pull — i. taking out a book from a table drawer

   c. Stretch — ii. using a bow and an arrow

   d. Acceleration — iii. a ball rolling down an incline

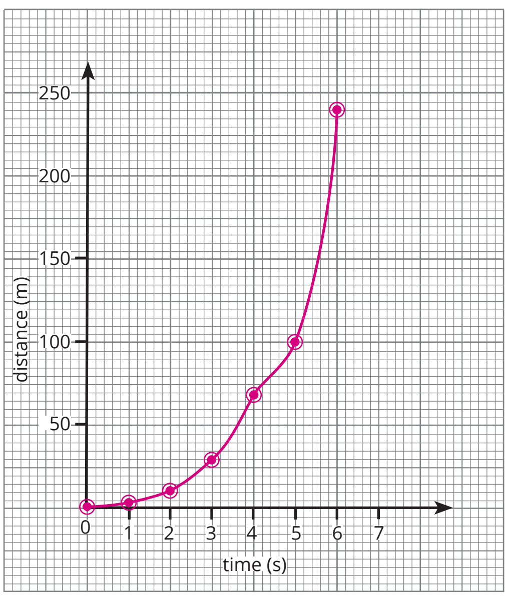
D. Short Answer Type-II Questions

1.

S.No.	Parameter	Balanced forces	Unbalanced forces
1.	Resting body (state of rest)	Balanced forces do not change the state of rest of a body, i.e. if the body is at rest, it will remain at rest.	Unbalanced forces change the state of rest of a body, i.e. they can move a body at rest.
2.	Moving body(state of motion)	They do not change the state of motion of a body, i.e. if a body moves with constant velocity, it will continue to move with the same velocity.	They can bring about a change in the state of motion of a body, i.e. they can bring a moving body to rest.

3.	Acceleration	They do not produce any acceleration. Balanced forces make the body move with constant velocity.	Any body moving at constant speed gets accelerated or decelerated due to the action of unbalanced forces.
4.	Change	They can change the shape of the body but not the direction of the moving body.	They can change both the shape and also the direction of motion of the body.
5.	Resultant force	The resultant of all the forces acting on the body is zero.	The resultant of all the forces acting on the body is not zero.

2. The forces acting on the object are unbalanced forces. We can infer that unbalanced forces are acting on the body because the body is getting accelerated with time.



P. 68–69 Check Your Progress 2

A. Multiple-choice Questions

1. a. Pencil

2. a. A has more inertia than B

3. c. law of inertia

4. a. inertia of rest

5. b. inertia of motion

B. Very Short Answer Type Questions

1. Every body continues to be in its state of rest or of uniform motion in a straight line unless it is compelled by some external applied force to change that state. For example, a book lying on a table is at rest. It will remain so unless someone picks it up or moves.

2. Initially both the tree and the fruits hanging to its branches are in the state of rest. When the branches of the tree are shaken, it is set into motion while the fruits remain in the state of rest due to the inertia of rest. Thus, the fruits get detached from the branches and fall down due to gravitational pull.

3. A cyclist riding along a road does not come to rest immediately after he stops pedalling because the bicycle continues to move forward due to the inertia of motion but eventually it comes to rest as a result of the retarding action of friction.

4. Initially, both the piece of paper and the pile of books are in the state of rest. When the piece of paper placed under a pile of books is suddenly pulled, it is set into motion, while the pile of books remains in the state of rest due to the inertia of rest. Thus, the pile of books does not fall.

5. It is advised to tie the luggage kept on the roof of the bus with a rope because if it is not tied, it will slide and fall on the following account.

Initially, if the bus is in the state of rest, the luggage will also be in the state of rest. When the bus starts suddenly the luggage tends to remain in the state of rest due to the inertia of rest. Hence, it may fall. If the bus is in the state of motion the luggage is also in the state of motion. When the bus suddenly stops, the luggage tends to remain in the same state of motion due to the inertia of motion. As a result, the luggage can be thrown in the forward direction and fall. If the bus takes a sharp turn on the road, the luggage will resist any change in its state or its direction due to inertia. As a result, the luggage can be thrown sideways and fall.

C. Short Answer Type-I Questions

1. The inherent property of a body by virtue of which it resists any change in its state of rest or of uniform motion in a straight line on its own is called its inertia. According to Newton's first law of motion, a body continues to be in its state of rest or of uniform motion in a straight line unless it is compelled by some external applied force to change that state. This means a body on its own cannot change its state of rest or uniform motion along a straight line. Hence, Newton's first law defines inertia. Example: When a passenger is sitting or standing in a stationary bus, both the bus and the passenger are at rest. When the bus starts, the lower part of the passenger's body starts moving forward with the bus. But the upper part of the body tends to remain in the state of rest due to inertia of rest. As a result the passenger tends to fall backward.

2. A rubber ball is easier to move than a stone of the same size. Hence, the stone has higher inertia and we know that a stone of the same size as the ball has higher mass. Similarly a toy car is easier to move than a real car by pushing and the latter has higher mass and thereby higher inertia.

D. Short Answer Type-II Questions

1. Inertia is a property of matter that resists changes in an object's motion. An object's inertia is directly proportional to its mass; the heavier an object is, the more inertia it has. Hence, a body's mass measures its inertia. For example, a rubber ball is easier to move than a stone of the same size, because the stone has higher inertia and we know that a stone of the same size as the ball has higher mass.

2. Take an empty and dry glass tumbler. Place a square piece of thick, smooth card over the mouth of the glass tumbler. Place a five rupee coin at the centre of the card. Now, flick the card horizontally striking it hard with your finger. The card piece flies away and the coin falls into the glass. This is because initially both the card and the coin are at rest. When the card is flicked, it comes into motion. The coin, however, remains at rest due to the inertia of rest, i.e. it tries to maintain its state of rest due to its inertia of rest. As a result, only the card flies away and the coin falls into the glass tumbler due to gravity.

3. **a.** When a passenger is sitting or standing in a stationary bus, both the bus and the passenger are at rest. When the bus starts, the lower part of the passenger's body starts moving forward with the bus. But the upper part of the body tends to remain in the state of rest due to inertia of rest. As a result the passenger tends to fall backward.

b. Initially, the entire glass is in the state of rest. When a bullet strikes the glass pane, the part of glass pane which comes in contact with the bullet immediately shares the large velocity of the bullet and flies away making a hole. The remaining part of the glass, due to inertia of rest, remains at rest and is not cracked.

c. When a passenger is sitting or standing in a bus, both the bus and the passenger are in the state of uniform motion. When the bus stops suddenly, the lower part of the passenger's body comes to rest along with the bus. The upper part of his body tends to remain in the state of motion due to its inertia of motion. As a result, the passenger falls forward.

d. An athlete runs a certain distance before taking a long jump because in doing so, he acquires inertia of motion. The velocity acquired by running is added to the velocity of the athlete at the time of jump. Hence, he can jump over a longer distance due to the increased inertia of motion.

e. When the carpet is beaten with a stick, the carpet and the dust particles are set in motion. The carpet comes to rest after some time, while the dust particles go on moving and fall down due to gravity.

f. A person jumping out of a speeding bus may get seriously injured because so long as he is in the moving bus, his body is in a state of motion, the moment he jumps of the bus his body tends to continue to be in the state of motion and hence, fall in the forward direction (the direction in which the bus is moving).

P. 76-77 Check Your Progress 3

A. Multiple-choice Questions

1. **c.** become half.
2. **d.** kg m/s
3. **c.** $F = ma$
4. **c.** 1 : 1
5. **a.** 1 : 3

B. Very Short Answer Type Questions

1. The linear momentum of a body of mass m travelling with a velocity v is defined as the product of its mass and velocity.

$$p = mv$$

Its SI unit is kilogram metre per second.

2. Momentum is directly proportional to mass. A cricket ball is heavier than a tennis ball, therefore, a cricket ball has a higher mass. Since both are thrown with the same speed, the cricket ball will possess higher momentum.

3. Magnitude of momentum is the product of mass and speed.

4. One newton is the force which when acting on a mass of 1 kg produces in it an acceleration of 1 m/s^2 in its own direction.

5. The forces which act on the bodies for short time are called impulsive forces. For example, forces involved while hitting a ball with a bat.

6. Units of impulsive force is newton second or kg m/s.

7. **a.** From Newton's second law of motion

$$F = ma$$
$$a = \frac{F}{m}$$

Hence, from the above equation acceleration and mass share an inverse relationship.

b. $F = ma$

Force and acceleration are directly proportional to each other.

c. $I = F \times t$

Impulse is change in momentum.

8. According to Newton's second law of motion 'The rate of change of momentum of a body is directly proportional to the applied unbalanced force in the direction of force.'

9. Force acting $F = 5$ N, Mass $m = 10$ kg

From Newton's second law of motion $F = ma$

or, $5 = 10 \times a$

$a = 0.5\ m/s^2$

Therefore, acceleration produced is 0.5 m/s^2.

10. **a.** A karate player breaks a pile of tiles in a single blow by moving his hand very fast. By doing this he increases the rate of change of momentum (by decreasing the time). In doing so, the entire momentum of the hand is reduced to zero in very short time interval. In other words, the rate of change of momentum is large. According to the second law of motion, the resultant force delivered on the pile of tiles is large enough to break it in a single blow.

b. A cricketer moves his arms backwards in the direction of ball while taking a catch so as to decrease the rate of change of momentum by increasing the time. The entire momentum of the ball is reduced to zero in a long time interval. As a result, the fielder has to apply a small force on the ball. In reaction, the ball also applies less force and the palms of the player are not injured. If the ball is stopped suddenly, then the entire momentum is reduced to zero in a very short time interval which will cause a larger rate of change of momentum. As a result, the fielder will have to apply a large force on the ball. In reaction the ball will also apply a large force on the fielder which might hurt his palms.

c. In the high jump athletic events, the athletes are made to fall on a cushioned bed or a sand bed to decrease the rate of change of momentum by increasing the time. While jumping from a height on a heap of sand, athletes feet move inside the sand slowly. The entire momentum of the body is reduced to zero in a long time interval. The impact of the reaction force is small, hence the athlete is not injured.

d. Shockers are provided in vehicles to decrease the rate of change of momentum by increasing the time interval and hence reducing the impact force during the jerks. This will also reduce the hardness of the shocks when the vehicles move over an uneven road.

C. Short Answer Type-I Questions

1. Consider a body of mass m having an initial velocity u. Suppose a force F acts on this body for time t. Let the final velocity of the body be v.

Initial momentum of the body $(p_i) = mu$

Final momentum of the body $(p_f) = mv$

Change in momentum $= p_f - p_i = mv - mu$
$= m(v - u)$

Rate of change of momentum

$$= \frac{\text{Change in momentum}}{\text{Time taken}}$$
$$= \frac{m(v-u)}{t} \quad \text{(i)}$$

We know that $v = u + at$

Therefore, $a = \frac{v-u}{t}$ (ii)

Substituting the value of (ii) in (i), we get

Rate of change in momentum $= ma$

According to Newton's second law of motion

$F \propto$ rate of change of momentum

Therefore $F \propto ma$

or $F = k \times m \times a$

when $k = 1$, $F = ma$

2. Consider a body of mass m having an initial velocity u. Suppose a force F acts on this body for time t. Let the final velocity of the body be v.

Initial momentum of the body $(p_i) = mu$

Final momentum of the body $(p_f) = mv$

Change in momentum $= p_f - p_i = mv - mu = m(v - u)$

Rate of change of momentum

$$= \frac{\text{Change in momentum}}{\text{Time taken}}$$

$$= \frac{m(v-u)}{t} \quad \text{(i)}$$

We know that $v = u + at$

Therefore, $a = \dfrac{v-u}{t}$ (ii)

Substituting the value of (ii) in (i), we get

Rate of change in momentum = ma

According to Newton's second law of motion

$F \propto$ Rate of change of momentum

3. The rate of change of momentum of a body is directly proportional to the applied unbalanced force in the direction of force.

4. Impulse of force is a measure of total effect of the force applied for a short time.

5. Impulse is given by the product of the force and time for which the force acts on the body, i.e.

Impulse = Force × Time

$I = F \times t$

From Newton's second law of motion,

$$\text{Force} = \frac{\text{Change in momentum}}{\text{Time taken}}$$

$F \times t$ = Change in momentum

or Impulse = Change in momentum.

6. Force acting = 10 N

Mass of the body = 2 kg

Applying $F = ma$

$10 = 2 \times a$

$$a = \frac{10}{2} = 5 \text{ m/s}^2$$

7. Mass of the body, m = 3 kg

Initial velocity, u = 40 m/s

Final velocity, v = 10 m/s

Time = 10 s

Retarding force F = ?

We know that

$$F = \frac{mv - mu}{t} = \frac{m(v-u)}{t}$$

$$= \frac{30(10-40)}{10} = \frac{-90}{10} = -9$$

Hence, the retarding force is 9 N.

8. Mass of the ball, m = 450 g

$$\text{Velocity} = 120 \text{ km/h} = \frac{120 \times 1000}{60 \times 60} \text{ m/s}$$

$$= \frac{100}{3} \text{ m/s}$$

$$\text{Momentum} = m \times v = 450 \times \frac{100}{3} = 15000 \text{ g m/s}$$

= 15 kg m/s.

9. Mass of the body, m = 1500 kg

Initial velocity, u = 40 m/s

Final velocity, v = 50 m/s

Change in momentum

$= mv - mu = m(v - u)$

$= 1500(50 - 40)$

$= 1500 \times 10 = 15000$ kg m/s

10. a. Mass of the cricket ball m = 100 g

Speed of the ball, or initial velocity, v_1 = 30 m/s

Initial momentum, $p_1 = mv_1 = 100 \times 30 = 3000$

After 0.03 s when the ball is brought to rest,

Final velocity, $v_2 = 0$

Final momentum = 100 × 0 = 0

Change momentum = 0 – 3000 = – 3000 g m/s

= – 3 kg m/s

b. Average force applied by the player

$$\text{Force} = \frac{\text{Change in momentum}}{\text{Time}}$$

$$= \frac{-3}{0.03} = -100 \text{ N}$$

11. Mass of the body = 500 g = 0.5 kg

Force acting on it = 0.01 N

$F = ma$

$0.01 = 0.5 \times a$

$$a = \frac{0.01}{0.5} = 0.02 \text{ m/s}^2$$

D. Short Answer Type-II Questions

1. Newton's first law of motion is contained in Newton's law second of motion. According to the second law of motion

$$F = ma \quad \text{(i)}$$

i. If no external force is acting on the object at rest, we can write

$$F = 0 \quad \text{(ii)}$$

From (i) and (ii), we get

$m \times a = 0$

Since m = 0, a = 0. Thus, a body will not be accelerated. In other words, a body at rest will continue to be in the state of rest if no external force acts on it.

ii. If no external force is acting on the object in motion, according to Newton's second law of motion,

F = Rate of change of momentum

$$F = \frac{mv - mu}{t}$$

If $F = 0$, then

$$\frac{mv - mu}{t} = 0$$

or $$mv - mu = 0$$

or $$v = u$$

This means that if no external force is applied on the moving object, then its initial and final velocities are equal. It means that the body will continue to be in the state of uniform motion along a straight line if no external force acts on it.

2. Mass of body A = m

Velocity of body A = v

Mass of body B = m

Velocity of body B = $3v$

a. Since both are of same masses their inertia will be the same. Hence, their ratio will be 1 : 1.

b. Momentum of body A = Mass × Velocity

$= m \times v = mv$

Momentum of body B = $m \times 3v = 3mv$

Hence, ratio of momenta of the two bodies will be 1 : 3.

c. To calculate force needed to stop them in time t. Since upon stopping, the bodies will come to rest, the final velocities of both bodies will be 0.

In that case, $F = \frac{mv - mu}{t}$

For body A, initial velocity is v and final velocity is 0. Substituting the value of u and v in the above equation, we get

$$F = \frac{0 - mv}{t} = -\frac{mv}{t}$$

(Please note that we have taken the initial velocity as v and not as u).

Similarly for body B, initial velocity is $3v$ and final velocity is 0. Therefore,

$$F = \frac{0 - 3mv}{t} = -\frac{3mv}{t}$$

The ratio of force required to stop the two bodies A and B is

$$-\frac{mv}{t} : -\frac{3mv}{t} = 1 : 3.$$

3. Mass of the car = 2400 kg

Initial velocity, u = 20 m/s

Final velocity, v = 0

Time = 10 s

Retarding force F = ?

Retardation = ?

$$F = \frac{mv - mu}{t} = \frac{m(v - u)}{t}$$

$$= \frac{2400(0 - 20)}{10} = -4800$$

Therefore, the retarding force is 4800 N.

To calculate acceleration substitute the values of u, v and t in the equation

$v = u + at$

$0 = 20 + a \times 10$

or $-20 = 10a$

or $a = -2 \text{ m/s}^2$

Hence, the retardation is 2 m/s^2.

4. a. This is to increase the rate of change of momentum by increasing the time. In doing so, entire momentum of the car is reduced to zero in a long time interval. As a result, the car applies less force and hence the impact of the reaction force on the car is small. Whereas the impact of reaction force imparted by the concrete wall would be very large which might cause serious accident.

b. During a car accident, the car stops suddenly. The seat belts worn by the passengers of the car prevent them form falling forward suddenly. It enables the entire momentum to be reduced to zero in a long time interval.

c. Vehicle seats are provided with springs to reduce their hardness. When the passengers sit on the seats suddenly, the springs enable the seats to get compressed. The compression increases the duration of passengers coming to rest on the seat.

Since the rate of change of momentum is small, the passengers apply less force on the seats. The reaction force of seats becomes negligible.

d. Athletes come to stop slowly after finishing a race to decrease the rate of change of momentum by increasing the time interva and hence reducing the impact force. This will reduce or avoid any possible injury.

e. China dish and glassware are wrapped in a paper or straw before packing to avoid breakage. There are collisions of the packed ware due to jerks experienced during transportation. But the soft packing materials slow down their rate of change of momentum. The force of impact is reduced and items are not broken.

5. Mass of the body = 5 kg

Initial velocity, u = 10 m/s

Final velocity, v = 0

Initial momentum = Mass × Initial velocity

= 5 × 10 = 50 kg m/s

Final momentum = Mass × Final velocity

= 5 × 0 = 0 kg m/s

6. Mass of the car = 1600 kg

Initial velocity, u = 0

Final velocity, v = 30 m/s

Time = 20 s

a. Initial momentum = Mass × Initial velocity

= 1600 × 0 = 0 kg m/s

b. Final momentum = Mass × Final velocity

= 1600 × 30

= 48000 kg m/s

c. Rate of change of momentum

$$= \frac{mv - mu}{t} = \frac{m(v-u)}{t}$$

$$= \frac{1600(30-0)}{20} = \frac{1600 \times 30}{20}$$

= 2400 N

d. Acceleration of the car can be calculated from the equation

$v = u + at$

$30 = 0 + a \times 20$

$30 = 20a$

$$a = \frac{30}{20} = 1.5 \text{ m/s}^2$$

e. $$F = \frac{m\,(v-u)}{t}$$

$$= \frac{1600 \times (30-0)}{20}$$

= 2400 N

7. Given:

Mass of the body = 1.2 kg

Initial velocity u = 0

Final velocity, v = 2 m/s

Time = 0.15

Acceleration, $a = \frac{v-u}{t} = \frac{(2-0)\text{ m/s}}{0.1\text{ m/s}^2} = 20\text{ m/s}^2$

Force, F = ma

= 1.2 kg × 20 m/s^2

= 24 N.

8. a. Mass of the vehicle = 1000 kg

Initial velocity = 20 m/s

Final velocity = 0

Time t = 5 s

Distance covered s = 50 m

Acceleration a = ?

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

$-400 = 2as$

$-400 = 2 \times a \times 50$

$$a = -\frac{400}{100} = -4 \text{ m/s}^2$$

b. Unbalanced force acting of the vehicle,

$F = ma$

$F = 1000 \times -4 = -4000$ N

c. The actual force applied may be slightly less than that calculated because of the frictional force would also contribute to the stoppage of the vehicle.

9. Mass of the ball = 10 g = 0.01 kg

Initial velocity = 50 m/s

Final velocity = 70 m/s

Time = 2 s

a. Initial momentum = 0.01 × 50 = 0.5 kg m/s

b. Final momentum = 0.01 × 70 = 0.7 kg m/s

c. Rate of change of momentum

$$= \frac{mv - mu}{t} = \frac{m(v-u)}{t}$$

$$= \frac{0.01(70-50)}{2} = 0.1 \text{ kg m/s}^2$$

d. Applying $v = u + at$

$70 = 50 + a \times 2$

$70 - 50 = 2a$

$a = 10 \text{ m/s}^2$

e. Magnitude of force $F = ma = 0.01 \times 10 = 0.1$ N

10. Mass of the body = 100 kg

Initial velocity = 0 (since the body is at rest)

Distance covered = 100 m

Time taken = 5 s

a. Velocity acquired (final velocity)

$$= \frac{\text{Distance covered}}{\text{Time taken}}$$

$$= \frac{100}{5} = 20 \text{ m/s}$$

b. To calculate acceleration produced by the force applying $v = u + at$

$$20 = 0 + a \times 10$$

(time for which force acts on the body is 10 s)

$$a = 2 \text{ m/s}^2$$

c. Magnitude of force

$$F = ma$$
$$= 100 \times 2 = 200 \text{ N}$$

P. 86-87 Check Your Progress 4

A. Multiple-choice Questions

1. **c.** backwards
2. **b.** downwards
3. **c.** third law of motion
4. **b.** different bodies in opposite direction
5. **c.** 10 N in the opposite direction

B. Very Short Answer Type Questions

1. To every action, there is an equal and opposite reaction; action and reaction forces act on different bodies.
2. A book lying on the table exerts a force acting downwards equal to its weight on the table. This is called action. The table in turn exerts a force on the book in the upward direction. It is called reaction.
3. **a.** When a gun is fired, the bullet goes out due to the force applied on it through the trigger (this is action). According to Newton's third law of motion, the gun recoils backwards due to the reaction acting on it in the opposite direction.

   b. When we run, our foot pushes the ground backwards. In turn the ground pushes our foot forward with an equal and opposite force. The reaction exerted by the ground makes us run.

   c. When a man jumps out of the boat, he pushes the boat backwards. The boat exerts an equal and opposite force on the man in the forward direction which helps him move forward. Since the boat is in water it moves backward due to action force exerted by the man.

   d. While hammering a nail, the force of the hammer on the nail is the action. According to Newton's third law of motion, the nail exerts an equal and opposite force on the hammer. Since we hold the hammer firmly, our hand experiences the force due to reaction and get hurt.

   e. In jet planes, the fuel is burnt to produce a large quantity of gases. These hot gases come out of a nozzle with a great force. According to Newton's third law of motion, the equal and opposite reaction pushes the jet plane upwards with a great speed.

   f. When a swimmer pushes the water in backward direction, the water pushes the swimmer in forward direction with equal force.
4. In the absence of an external force the total momentum of all the bodies of a system remains constant or conserved.
5. Mass of the bullet (m_1) = 0.05 kg

   Mass of the gun (m_2) = 4 kg

   Velocity of the bullet (v_1) = 280 m/s

   Let the recoil velocity be v_2.

   Before firing, both the gun and the bullet are at rest. So, the total momentum of the system before firing = 0 (i)

   According to law of conservation of momentum,

   Total momentum of the system before firing = Total momentum of the system after firing (ii)

   From equations (i) and (ii), we get

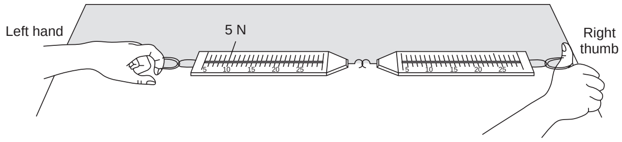
   0 = Total momentum of the system after firing

   or, $m_1v_1 + m_2v_2 = 0$

   $$0.05 \times 280 + 4v_2 = 0$$
   $$14 + 4v_2 = 0$$
   $$-14 = 4v_2$$
   $$v_2 = \frac{-14}{4} = -3.5 \text{ m/s}$$

C. Short Answer Type-I Questions

1. Newton's third law of motion can be demonstrated by the following experiment. Take two spring scales both of which read from 0 to 10 N. Hook the top portion of one spring scale around your right thumb. Position your right hand on the right edge of a table. Hook a second spring scale to the first scale so the bottom portion of the second scale is hooked to the bottom portion of the first scale. With the two scales attached, hold your right hand steady so it does not move. With your left hand pull horizontally on the top portion of the second spring scale until the reading on the scale measures 5 N. Look at the reading on the other spring scale. It will read 5 N. The same force is exerted on both scales in the activity due to the third law of motion.



2. a. When a bullet is fired from a gun, the gases produced in the barrel exerts a tremendous force on the bullet (action force). As a result, the bullet moves forward with a great velocity called the muzzle velocity. The bullet at the same time exerts an equal force on the gun in the opposite direction (reaction force). Due to this the gun moves backwards. This backward motion of the gun is called the recoil of the gun. The velocity with which the gun moves backwards is called the recoil velocity. Let '*M*' be the mass of the gun and '*m*' that of the bullet. Before firing both are at rest. After firing let '*V*' be the velocity of the gun and '*v*' that of the bullet. By law of conservation of linear momentum,

Initial momentum of gun and bullet = Final momentum of gun and bullet.

The initial momentum of the gun and the bullet is equal to zero since they are initially at rest.

Final momentum after firing = $MV + mv = 0$

b. The operation of a rocket illustrates the conservation of momentum. Just before launching, the momentum of the rocket is zero. When the rocket is fired, a jet of hot gases is produced with a high velocity through the nozzle. The jet of gases acquires a momentum downwards. Hence, the rocket acquires a momentum of equal magnitude in opposite direction. Thus, the rocket moves upwards.

3. Mass of the bullet (m_1) = 10 g = 0.01 kg

Mass of the wooden block (m_2) = 900 g = 0.9 kg

Initial velocity of the bullet (u_1) = 400 m/s

Final velocity of the bullet = 0

(as it gets embedded in the block)

Initial velocity of the wooden block = 0

(as it is at rest)

Let the velocity acquired by the block be v_2.

According to law of conservation of momentum,

Total momentum of the system before firing = Total momentum of the system after firing (i)

Total momentum of the system before firing

$= m_1u_1 + m_2u_2$

$= 0.01 \times 400 + 0.9 \times 0 = 4$ (ii)

Total momentum of the system after firing

$= m_1v_1 + m_2v_2$

$= 0.01 \times 0 + 0.9 \times v_2 = 0.9v_2$ (iii)

Applying equation (i), (ii) and (iii)

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$4 = 0.9v_2$

$v_2 = 4/0.9 = 4.4$ m/s

D. Short Answer Type-II Questions

1. a. A large amount of water ejecting from the nozzle of the hose-pipe is at a very high velocity with a very large force. According to Newton's third law of motion, the fireman holding the hose experiences an equal force but in opposite direction as a reaction. This force as reaction pushes the fireman, hence he holds the hose-pipe very tightly.

b. When we walk, our foot pushes the ground backwards. In turn the ground pushes our foot forward with an equal and opposite force. The reaction exerted by the ground makes us walk.

c. When we strike a rubber ball against a hard floor, the ball exerts a force on the floor. According to Newton's third law of motion, the floor exerts an equal and opposite force on the ball. The ball being light, rebounds.

2. Mass of the bullet (m_1) = 10 g = 0.01 kg

Mass of the gun (m_2) = 5 kg

Velocity of the bullet (v_1) = 400 m/s

Let the recoil velocity be v_2.

Before firing, both the gun and the bullet are at rest. So, the total momentum of the system before firing = 0 (i)

According to law of conservation of momentum,

Total momentum of the system before firing = Total momentum of the system after firing (ii)

From equations (i) and (ii), we get

0 = total momentum of the system after firing

or $m_1v_1 + m_2v_2 = 0$

$0.01 \times 400 + 5v_2 = 0$

$4 + 5v_2 = 0$

$-4 = 5v_2$

$v_2 = -4/5 = -0.8$ m/s

3. Mass of the object (m_1) = 2 kg

Initial velocity of the object (u_1) = 5 m/s

∴ Initial momentum of the object $= m_1 u_1 = 2 \times 5$

= 10 kg m/s

Mass of the wooden block (m_2) = 8 kg

Initial velocity of the wooden block (u_2) = 0 m/s (since it is at rest)

$\therefore$ Initial momentum of the wooden block = m_2u_2 = $8 \times 0 = 0$ kg m/s

Total momentum of the system before the impact = $m_1u_1 + m_2u_2 = 10 + 0 = 10$ kg m/s

Let the final velocity of the combined object and wooden block be v

Total momentum of the system after impact = $m_1v + m_2v = (m_1 + m_2)\ v = (2 + 8)\ v = 10v$

According to law of conservation of momentum,

Total momentum of the system before impact = Total momentum of the system after impact

or $10 = 10v$

or $v = 1$ m/s

P. 88 Higher Order Thinking Skills (HOTS) Questions

A. Multiple-choice Questions

1. **c.** It always goes away from the earth
2. **d.** decrease the rate of change of momentum
3. **c.** to resist any change in its state of motion.
4. **b.** 0 N
5. **b.** move forward.

B. Very Short Answer Type Questions

1. On a frictionless surface no force is needed to be applied to keep a body moving with a constant velocity.
2. The spring balance will show the reading as F.
3. When an object moves in a circular path at uniform speed.
4. Acceleration will remain same.

C. Short Answer Type-I Questions

1. A cricketer moves his arms backwards in the direction of ball while taking a catch so as to decrease the rate of change of momentum by increasing the time. The entire momentum of the ball is reduced to zero in a long time interval. As a result, the fielder has to apply a small force on the ball. In reaction, the ball also applies less force and the palms of the player are not injured. If the ball is stopped suddenly, then the entire momentum is reduced to zero in a very short time interval which will cause a larger rate of change of momentum. As a result, the fielder will have to apply a large force on the ball. In reaction, the ball will also apply a large force on the fielder which might hurt his palms.
2. If the bus takes a sudden sharp turn, the passengers' body will resist any change in their state of their direction due to inertia. As a result, the passengers tend to fall sideways.
3. When the carpet is beaten with a stick, the carpet and the dust particles are set in motion. The carpet comes to rest after some time, while the dust particles go on moving and fall down due to gravity.

D. Short Answer Type-II Questions

1. When a pile of carrom coins is hit horizontally by a striker, the lowermost coin at the bottom of the pile is removed as the coins are initially at rest, they tend to maintain the state of rest due to inertia. Hence, only the lowermost coin gets displaced.
2. When two people travel on the two wheeler, their bodies are in motion when the vehicle is in motion. When the driver of a two wheeler applies brakes, he brings the vehicle to rest, but the body of the pillion rider tends to continue in the state of motion and hence falls forward.
3. A cricketer moves his arms backwards in the direction of ball while taking a catch so as to decrease the rate of change of momentum by increasing the time. The entire momentum of the ball is reduced to zero in a long time interval. As a result, the fielder has to apply a small force on the ball. In reaction, the ball also applies less force and the palms of the player are not injured. If the ball is stopped suddenly, then the entire momentum is reduced to zero in a very short time interval which will cause a larger rate of change of momentum. As a result, the fielder will have to apply a large force on the ball. In reaction the ball will also apply a large force on the fielder which might hurt his palms.

P. 89-92 Exercises

I. Multiple-choice Questions

1. **c.** Newton's third law of motion.
2. **d.** two bodies irrespective of their position and state of motion.
3. **d.** 0
4. **b.** along the tangent to the circle
5. **c.** both a. and b.

II. Fill in the blanks

1. sum
2. motion
3. Mass

4. zero
5. inertia

III. Assertion–Reasoning Type Questions

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

A. Very Short Answer Type Questions

1. Force = Rate of change of momentum
2. In rockets, the fuel is burnt to produce a large quantity of hot gases. These hot gases come out of a nozzle with a great force. According to Newton's third law of motion, the equal and opposite reaction pushes the rocket upwards with a great speed.
3. Yes. Centripetal force.
4. A body can be at rest even if forces act on it, when the forces acting are balanced forces.
5. In order to double the acceleration, either the mass must be halved or the force must be doubled, since $F = ma$.
6. Inertia
7. Mass and velocity
8. Zero
9. An athlete runs a certain distance before taking a long jump because in doing so, he acquires inertia of motion. The velocity acquired by running is added to the velocity of the athlete at the time of jump. Hence, he can jump over a longer distance due to the increased inertia of motion.
10. A cricket ball will have more inertia in comparison to the rubber ball of the same size as cricket ball is heavier than the rubber ball. The heavier the body, greater the inertia.

B. Short Answer Type-I Questions

1. When someone jumps out of the boat, he pushes the boat backwards. The boat exerts an equal and opposite force on the person in the forward direction which helps him move forward. Since the boat is in water it moves backwards due to action force exerted by the person.
2. When we kick a stone, we exert a force on the stone and it moves. In turn the stone exerts an equal force in opposite direction. That is the reason why we get hurt.
3. While falling on a sand track, we reduce the rate of change of momentum by increasing the time interval. Our body moves into the sand slowly, whereas on a concrete the entire momentum of the body is brought to zero suddenly and the impact felt is more. Hence, we get hurt.

C. Short Answer Type-II Questions

1. Initially, both the piece of paper and the pile of books are in the state of rest. When the piece of paper placed under a pile of books is suddenly pulled, it is set into motion, while the pile of books remains in the state of rest due to the inertia of rest. Thus, the pile of books does not fall.
2. Force acting on a body can bring about several changes as discussed under.
   - Force can cause motion in a stationary body. For example, a book placed on the table moves when pushed.
   - Force can stop a moving body. For example, a moving ball can be stopped by the force of our hand.
   - Force can change the direction of motion. For example, when a batsman hits the ball with his bat, the direction of the moving ball changes.
   - Force can change the speed of a moving body. For example, when more force is applied on the pedals by cyclist, it moves faster.
3. A bicycle moves when we apply force on the pedals. Upon stopping pedalling, the bicycle stops due to absence of force needed to move it.

D. Long Answer Type Questions

1. Law of conservation of momentum states that in absence of an external force, the total momentum of all the bodies of a system remains constant.
   a. When a gun is fired, the bullet goes out due to the force applied on it through the trigger (this is action). According to Newton's third law of motion, the gun recoils backwards due to the reaction acting on it in the opposite direction.
   b. In rockets, the fuel is burnt to produce a large quantity of hot gases. These hot gases come out of a nozzle with a great force. According to Newton's third law of motion, the equal and opposite reaction pushes the rocket upwards with a great speed.
2. **Newton's first law of motion:** Every body continues to be in its state of rest or of uniform motion in a straight line unless it is compelled

by some external applied force to change that state.

Newton's second law of motion: The rate of change of momentum of a body is directly proportional to the applied unbalanced force in the direction of force.

Newton's third law of motion: To every action, there is an equal and opposite reaction; action and reaction forces act on different bodies.

Mass of the body = 12.5 kg

Acceleration to be produced = 2 m/s^2

Applying $F = ma$

$F = 12.5 \times 2 = 25$ N

E. Numerical Problems

1. Force exerted = 12 N

Mass of the body = 6 kg

Acceleration = ?

Applying $F = ma$

$12 = 6 \times a$

$a = 2$ m/s^2

2. Mass of the body = 5 kg

Acceleration = 2 m/s^2

Force = ?

We know that F = ma

$F = 5 \times 2 = 10$ N

3. Mass of the body = 1000 kg

Initial velocity u = 10 m/s

Final velocity v = 0 m/s

Distance covered s = 100 m

Acceleration = ?

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

$-(10)^2 = 2 \times a \times 100$

$-100 = 200a$

$a = -0.5$ m/s^2

Therefore, retardation is 0.5 m/s^2

Now to calculate the retarding force F, we apply

$F = ma$

$F = 1000 \times (-0.5) = -500$ N

The negative sign indicates that the force is a retarding force.

4. Initial velocity of the truck $u = 0$

Distance covered = 300 m

Time taken = 10 s

Mass of the truck = 8000 kg

Acceleration = ?

Force = ?

To calculate acceleration a, we apply

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

$300 = 0 \times 10 + \frac{1}{2}a \times (10)^2$

$300 = 0 + 50a$

$a = \frac{300}{50} = 6$ m/s^2

Substituting the value of a in $F = ma$, we get

$F = 8000 \times 6 = 48{,}000$ N.

5. This question does not require the application of any formula. It is a simple logical question.

We need to calculate the value of $(v - u)$ first.

Initial velocity u = 2.4 m/s

Final velocity v = 4.9 m/s

Change in velocity $(v - u) = 4.9 - 2.4 = 2.5$ m/s

If the force acting on the body for 0.5 s brings about a change of 2.5 m/s in velocity.

Same force acting for 2.5 s will bring about change.

Change in velocity brought about by the force in 2.5 s = $\frac{2.5 \times 2.5}{0.5}$ = 12.5 m/s

6. Initial velocity, $u = 0$

Let the final velocity be v

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

$v^2 = 2 \times 10 \times 0.4$

$v = 2\sqrt{2}$

Momentum = Mass × Velocity

Momentum = $5 \times 2\sqrt{2}$ = 14 kg m/s

7. Mass of the body = 250 g = 0.25 kg

Momentum = 7.5 kg m/s

Momentum = Mass × Velocity

7.5 = 0.25 × Velocity

Velocity = $\frac{7.5}{0.25}$ = 30 m/s

8. Initial velocity of the car = 0 (since it is at rest)

Final velocity = 72 km/h = $\frac{72 \times 1000}{60 \times 60}$ m/s = 20 m/s

Time = 20 s

Mass = 1000 kg

To calculate acceleration a, we apply

$v = u + at$

$20 = 0 + a \times 20$

$a = 1$ m/s^2.

Substituting the value of acceleration in the equation $F = ma$

$F = 1000 \times 1 = 1000$ N

To calculate the distance travelled

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

$$s = 0 \times t + \frac{1}{2} \times 1 \times (20)^2$$

$$= 200 \text{ m}$$

9. Mass of the car = 800 kg

Initial velocity u = 54 km/h = 15 m/s

Final velocity = 0

Distance covered s = 15 m

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

$$-(15)^2 = 2 \times a \times 15$$

$$-225 = 30a$$

$$a = -\frac{225}{30} = -7.5 \text{ m/s}^2$$

Substituting the value of retardation in the equation $F = ma$

$$F = 800 \times 7.5 = 6000 \text{ N}$$

10. Mass of the shell (m) = 40 kg

Velocity (v) = 72 km/h = 20 m/s

After explosion, mass of one piece (m_1) = 15 kg

Mass of other piece (m_2) = 40 – 15 = 25 kg

Velocity of one piece (v_1) = 0 (as it comes to rest)

Velocity of other piece (v_2) = ?

According to law of conservation of momentum,

Total momentum of the system before explosion = Total momentum of the system after explosion

Total momentum of the system before explosion = $mv = 40 \times 20 = 800$

Total momentum of the system after explosion = $m_1v_1 + m_2v_2 = 15 \times 0 + 25 \times v_2$

$$mv = m_1v_1 + m_2v_2$$

$$800 = 15 \times 0 + 25 \times v_2$$

$$800 = 25v_2$$

$$v_2 = 32 \text{ m/s}$$

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. a. i. Newton's first law of motion

b. iii. to resist a change in its state of motion.

c. i. mass of the object

d. ii. reduce the force exerted by cricket ball.

e. ii. inertia of motion.

2. a. i. Granite

b. iv. 0 N

c. i. kg·m/s

d. iii. 10 N

e. ii. opposite to the direction of motion of body

G. Value-Based Questions (Optional)

1. a. Nishant was not able to push the box alone as the force applied by him was balanced by the large force of friction opposing the motion of the box.

b. The force opposing the movement of the box is frictional force.

c. The values we learn from Siddhant are that we should be kind and helpful. We should not hesitate to help someone who is in need.

2. a. If the bus stops suddenly. Rubina might fall forward because when the bus is moving, both the bus and Rubina are in the state of uniform motion. When the bus stops suddenly, the lower part of Rubina comes to rest along with the bus. The upper part of her body tends to remain in motion due to the inertia of motion. As a result, Rubina might ban or fall forward.

b. This shows that the elderly person cares about his co-passengers. He is very kind and helpful and does not want anyone to get hurt.

CHAPTER – 3

GRAVITATION

P. 99-100 Check Your Progress 1

A. Multiple-choice Questions

1. **d**. gravitational force
2. **c**. centripetal force
3. **c**. 6.67×10^{-11} Nm^2/kg^2
4. **b**. decrease
5. **c.** motion of electrons around the nucleus.

B. Very Short Answer Type Questions

1. The force with which any two particles in the universe get attracted is called gravitational force.
2. The force with which any two particles in the universe get attracted is called gravitational force whereas, the force of gravitation exerted by earth is called gravity.
3. Newton stated that the fall of the apple from the tree required the presence of some force because before getting detached from the tree, the apple is at 0 velocity and after getting detached it falls to the ground with some acceleration. Then he concluded that earth, by virtue of an attractive force attracted not only the apple, but every substance to its centre.
4. Henry Cavendish
5. The universal gravitational constant is equal to the force of attraction acting between two bodies each of unit masses (i.e. 1 kg) whose centres are placed unit distance (i.e. 1 m) apart. The SI unit of the G is N m^2/kg^2.
6.
   - The gravitational force between the earth and moon makes the moon move around the earth.
   - The gravitational pull of the earth is responsible for holding the atmosphere near the surface of the earth.
   - The gravitational pull of earth is responsible for the fall of rain and snow towards the centre of the earth.
7. Gravitational force
8. The value of G does not depend on nature of the bodies and nature of medium between the bodies.
9. The value of G depends on the masses of the bodies and the distance between them.
10. Two objects in a room do not move towards each other due to gravitational force according to Newton's universal law of gravitation because the gravitational force is very negligible for small objects.

C. Short Answer Type-I Questions

1. Newton's Universal Law of Gravitation states that 'Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The force acts along the line joining the centres of the two bodies.
2. Consider two bodies A and B of masses m_1 and m_2 respectively that have a distance d between their centres. Let the force of attraction be F.

   According to Newton's universal law of gravitation, the magnitude of force between the two bodies is directly proportional to the product of their masses, i.e.

   $$F \propto m_1 m_2 \qquad \text{(i)}$$

   And also the magnitude of force between the two bodies is inversely proportional to the square of the distance between them, i.e.

   $$F \propto \frac{1}{d^2} \qquad \text{(ii)}$$

   combining equations (i) and (ii)

   $$F \propto \frac{m_1 m_2}{d^2}$$

   or $$F = G\frac{m_1 m_2}{d^2}$$
3. Newton's Universal Law of Gravitation is also called inverse square law because the force of attraction (F) between two bodies is inversely proportional to the square of the distance (d) between them.
4. Newton's Universal Law of Gravitation is also known as Universal law because it is applicable to all bodies, whether the bodies are big or small, whether they are terrestrial or celestial.
5. **a.** Centripetal force.

   b. When the stone is released, it travels in a straight line along the tangent to the circular path at that point. This is because the direction of velocity is along the tangent to the circle at any point.

D. Short Answer Type-II Questions

1. Before increasing the distance

   $$F = G\frac{m_1 m_2}{d^2}$$

After the distance is increased by 4 times, distance becomes 4d, then

$$F^1 = G\frac{m_x m_y}{(4d)^2} = G\frac{m_x m_y}{16\ d^2}$$

If both forces are to be the same then

$$\frac{F}{F^1} = 1$$

$$F = F^1$$

$$G\frac{m_1 m_2}{d^2} = G\frac{m_x m_y}{16\ d^2}$$

$$m_x\ m_y = 16\ (m_1 m_2).$$

Hence, the masses must be increased 16 times to keep the force constant.

2. **a.** The value of G will remain constant.
   b. The value of G will remain constant.
   c. The value of G will remain constant.
   d. The value of G will remain constant.

3. Mass of first body m_1 = 40 kg

   Mass of the second body m_2 = 25 kg

   Distance between the two bodies d = 2 m

   Gravitational constant = ?

   Force of attraction = 1.67×10^{-8} N

   From Newton's universal law of gravitation

   $$F = G\ \frac{m_1 \times m_2}{d^2}$$

   Substituting the values of F, m_1 *and* m_2 in the above equation

   $$1.67 \times 10^{-8} = G\ \frac{40 \times 25}{2 \times 2}$$

   $$1.67 \times 10^{-8} = G \times 250$$

   $$G = \frac{1.67 \times 10^{-8}}{250}$$

   $$= 6.68 \times 10^{-11}\ \text{N m}^2/\text{kg}^2$$

4. Mass of one object m_1 = 25 kg

   Mass of another object m_2 = 40 kg

   Distance between the two objects d = 10 m

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

   Force of gravitation $F = G\frac{m_1 m_2}{d^2}$

   $$F = \frac{6.67 \times 10^{-11} \times 25 \times 40}{(10)^2} = 6.7 \times 10^{-10}\ \text{N}$$

7. Mass of Jupiter = 1.9×10^{27} kg

   Mass of Sun = 1.99×10^{30} kg

   Distance between the two planets $d = 7.8 \times 10^{11}$ m

   Force of gravitation $F = G\frac{m_1 m_2}{d^2}$

   $$F = \frac{6.67 \times 10^{-11} \times 1.9 \times 10^{27} \times 1.99 \times 10^{23}}{(7.8 \times 10^{11})^2}$$

   $$= 4.15 \times 10^{23}\ \text{N}$$

P.106-108 Check Your Progress 2

A. Multiple-choice Questions

1. **c.** very small acceleration
2. **a.** 9.8 m/s^2
3. **c.** F
4. **c.** elliptical orbit
5. **c.** mass of the earth
6. **d.** on the ground
7. **c.** zero
8. **b.** one-sixth
9. initial velocity u = 0 (since before dropping, the object is at rest)

   Final velocity v = ?

   Acceleration due to gravity g = 9.8 m/s^2. Taking t = 2 s and substituting in the equation $v = u + at$

   $v = 0 + 9.8 \times 2$

   $\therefore\ v$ = 19.6 m/s

   Answer is **a.** 19.6 m/s
10. **c.** remains same as it goes up.

B. Very Short Answer Type Questions

1. The uniform acceleration produced in a body when it freely falls under the effect of gravity alone is known as acceleration due to gravity. Its SI unit is m/s^2.
2. According to Newton's third law of motion, 'To every action there is an equal and opposite reaction'. Action and reaction act on different bodies, but they act simultaneously. Newton's third law of motion is also applicable to the gravitational force also. If two bodies are attracted to each other by gravitational force then the force exerted by one body is equal and opposite to that exerted by the other body on the former.
3. Yes, a stone and the earth attract each other with an equal and opposite force but the mass of stone is very small, due to which force of earth produces a large acceleration on the stone. Whereas, the mass of earth is very large due to which the force on it due to the stone produces very small acceleration.

4. The moon attracts the earth and according to Newton's second law of motion acceleration produced in a body by any force is inversely proportional to the mass of the body. Since the mass of the earth is very large as compared to that of the moon, a very negligible acceleration is produced in the earth. Hence, we do not see the earth moving towards the moon.
5. Acceleration due to gravity is independent of the mass, size and shape of the body.
6. Galileo found that when two stones were dropped from the Leaning Tower of Pisa, they reached the ground simultaneously. He argued that the air offers resistance to the objects travelling through it. If the material is dense and its surface area is small, the resistance due to the air is quite small compared to a material having larger surface area.

C. Short Answer Type-I Questions

11. Yes, a stone and the earth attract each other with an equal and opposite force but the mass of stone is very small, due to which force of earth produces a large acceleration on the stone. Whereas, the mass of earth is very large due to which the force on it due to the stone produces very small acceleration.

2. We know that $g = \frac{GM}{R^2}$

   Value of acceleration due to gravity depends on gravitational constant G and, mass of the earth M and radius of the earth R. Since G and M are constants, g depends only on radius of the earth. The value of g changes with the height, depth and shape of the earth.

3. The earth is not a perfect sphere. It is flattened at the poles and bulges out at the equator. The equatorial radius R_e of the earth is about 21 km greater than the polar radius R_p

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

   or $g \propto \frac{1}{R^2}$

   Thus, as the radius of the earth is maximum at the equator, the value of g is minimum at the equator, and since the radius of the earth is maximum at the poles, the value of g is maximum at the poles. In other words the value of g increases as we go from the equator to the poles.

4. a. When a ball is thrown upwards its speed decreases.

   b. When a ball is dropped form a height, its speed increases.

5. Acceleration due to gravity depends upon the mass and radius of the earth.

6. We know that $g \propto \frac{1}{R^2}$.

   As per the above equation, the value of g is inversely proportional to the square of the distance form the centre of earth. As we go up the surface of earth, the distance from the centre of earth increases and hence the value of g decreases. That is the reason why the value of acceleration due to gravity is less on the mountains than on the plains.

7. If we drop a coin and a feather from a certain height, the coin will come down first as the mass of the coin is more and that of the feather. The air will offer a resistance to the feather travelling through it as these objects are not travelling in a vacuum. As these objects are not falling freely under gravity they will not reach ground simultaneously.

D. Short Answer Type-II Questions

1. Differences between G and g

Parameter	Universal gravitational constant	Acceleration due to gravity
Definition	It is equal to the force of attraction between two bodies of unit mass, whose centres are placed unit distance apart.	It is the uniform acceleration produced in a body when it falls freely under the effect of gravity alone.
SI unit	N m^2/kg^2	m/s^2
Numeric value	Very small 6.67×10^{-11} N m^2/kg^2	Large value $9.8\ m/s^2$
Variation	It has the same value at all places.	Its value changes from place to place.
Zero value	It is never zero.	It is zero at the centre of the earth.
Quantity	It is a scalar quantity.	It is a vector quantity.

2. Consider earth to be a spherical body of mass M and radius R with centre O. Suppose a body of mass m be placed on the surface of the earth where acceleration due to gravity is g. Let F be the force of attraction between the body and the earth.

According to Newton's Universal Law of Gravitation

$$F = G\frac{Mm}{R^2} \quad \text{(i)}$$

This force exerted by earth produces acceleration in the body due to which the body moves downwards according to Newton's second law of motion.

Force = Mass × Acceleration

or $F = ma$

The acceleration produced by the earth is known as acceleration due to gravity and represented by g. So, replacing a with g in the above equation, we get

$$F = mg \quad \text{(ii)}$$

Combining equations (i) and (ii), we get

$$mg = G\frac{Mm}{R^2}$$

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

3. Robert Boyle kept a coin and a feather in a big glass jar. The air inside the jar was removed by using a vacuum pump. After evacuation of air from the glass jar, the glass jar was inverted. Both feather and the coin fell to the bottom of the jar at the same time. Thus, he proved Galileo's argument that the acceleration produced in the free falling bodies is the same and does not depend on the masses of the falling bodies.

4. Mass of the stone m_1 = 2 kg

Mass of the earth $m_2 = 6 \times 10^{24}$ kg

Radius of the earth $R = 6.4 \times 10^6$

Force of attraction between the stone and earth

$$F = G\frac{m_1 m_2}{R^2}$$

Gravitational constant $G = 6.7 \times 10^{-11}$ Nm²/kg²

$$F = \frac{6.7 \times 10^{-11} \times 2 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2}$$

According to Newton's second law of motion

Force exerted by the stone $F = ma$

Equating both equations

$$\frac{6.7 \times 10^{-11} \times 2 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2} = 2 \times a$$

$$a = 9.8 \text{ m/s}^2$$

5. Mass of the planet, $M = 6 \times 10^{24}$ kg

Diameter of the planet = $12.8 \times 10^3 = 12.8 \times 16^6$ m

Therefore, radius, $R = 6.4 \times 10^6$ m

Universal gravitational constant $G = 6.7 \times 10^{-11}$

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

$$g = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24}}{(6.4 \times 10^6)^2} = 9.8 \text{ m/s}^2$$

6. Mass of the planet is half that of earth. And the radius is also half that of earth.

Now, we know

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

This equation clearly shows that the value of g is directly proportional to M and inversely to the square of the radius.

Reducing the mass by half, the value of g will also get reduced by half. Reducing the radius by half, the value of g will increase four times.

The value of g for earth is 9.8 m/s².

Now applying both the changes, the value of g the planet will be $\frac{9.8 \times 4}{2}$ = 19.6 m/s²

7. Acceleration due to gravity on moon = 1.67 m/s²

Radius of the moon = 1.74×10^6 m

We know that acceleration due to gravity

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

$$1.67 = \frac{6.7 \times 10^{-11} \times M}{(1.74 \times 10^6)^2}$$

$$M = \frac{1.67 \times (1.74 \times 10^6)^2}{6.7 \times 10^{-11}}$$

$$= 7.6 \times 10^{22} \text{ kg}$$

8. Let the mass of sun be M_S and mass of moon be M_M and mass of earth be M_E

Force exerted by sun on earth = $\frac{G M_S M_E}{R_{SE}^2}$ (i)

Force exerted by moon on earth = $\frac{G M_M M_E}{R_{ME}^2}$ (ii)

On dividing (i) by (ii), we get

$$\frac{\text{Force exerted by sun on earth}}{\text{Force exerted by moon on eath}}$$

$$= \frac{GM_S M_E}{R_{SE}^2} \times \frac{R_{ME}^2}{GM_M M_E}$$

$$= \left(\frac{M_S}{M_M}\right)\left(\frac{R_{ME}}{R_{SE}}\right)^2$$

$$= \left(\frac{1.989 \times 10^{30}}{7.347 \times 10^{22}}\right)\left(\frac{3.844 \times 10^5}{1.496 \times 10^8}\right)^2$$

$$= \left(\frac{1.989}{7.347} \times 10^8\right)\left(\frac{3.844}{1.496} \times 10^{-3}\right)^2$$

$= 1.7874 \times 10^2$

≈ 180

Force exerted by sun on earth = 180 (Force exerted by moon on earth)

Hence, sun exerts a greater force and by 180 times.

9. The acceleration will be 5 m/s^2 as the value of acceleration due to gravity is independent of mass of the body.

10. We know that

$$g \propto \frac{1}{R^2}$$

If the radius is increased by two times, the value of g will get reduced by four times. Hence, the value of g will be $\frac{9.8}{4}$ m/s^2 = 2.45 m/s^2.

P.111-112 Check Your Progress 3

A. Multiple-choice Questions

1. **b.** $u = v + gt$
2. **c.** zero
3. **c.** 10 s
4. **b.** zero.
5. **b.** less than the time taken by it to fall from the same height.

B. Very Short Answer Type Questions

1. Free falling body has uniform acceleration.
2. The final velocity when a body is thrown vertically upwards is zero because it stops after reaching maximum height.
3. **a.** When an object is thrown upwards, the acceleration due to gravity is taken as negative.

   b. When the object travels vertically downwards it is taken as positive.
4. In equations of motion, acceleration (a) and distance (s) are replaced by g and h respectively.
5. The initial velocity of a body dropped from certain height is zero.

C. Short Answer Type-I Questions

1. Initial velocity of the stone, $u = 0$

Final velocity, v =?

Height travelled = 80 m

g =10 m/s^2

From the equation $h = ut + \frac{1}{2} gt^2$

$80 = 0 \times t + \frac{1}{2} \times 10 \times t^2$

$80 = 5t^2$

$16 = t^2$

$t = 4$ s

Substituting the value of t in the equation $v = u + gt$

$v = 0 + 10 \times 4 = 40$ m/s

2. Height attained by the ball = 180 m

Final velocity = 0

(since it stops after reaching a certain height)

$g = -10$ m/s^2 (since the ball is thrown upwards)

Applying $v^2 - u^2 = 2gh$

$-u^2 = 2 \times (-10) \times 180$

$-u^2 = -3600$

$u = 60$ m/s

3. Time taken by the stone to reach the ground = 4 s

$g = 10$ m/s^2

Initial velocity of the stone = 0

We know, $h = ut + \frac{1}{2} gt^2$

$h = 0 \times t + \frac{1}{2} \times 10 \times (4)^2 = 80$ m

D. Short Answer Type-II Questions

1. a. The velocity at the highest point of the journey will be zero.

b. Initial velocity = 50 m/s

Final velocity = 0

$v^2 - u^2 = 2gh$

$0 - (50)^2 = 2 \times (-10) \times h$

$-2500 = -20h$

$2500 = 20h$

$h = 2500/20 = 125$ m

c. Applying $v = u + gt$

$0 = 50 + (-10) \times t$

$-50 = -10t$

$t = 5$ s

2. Height of the tower = 180 m

Initial velocity, $u = 0$

$g = 10\ m/s^2$

We know that $h = ut + \frac{1}{2}gt^2$

Substituting the values of h, g and u in the above equation

$$180 = 0 \times t + \frac{1}{2} \times 10 \times (t)^2$$

$$\frac{180}{5} = t^2$$

$$t = \sqrt{36} = 6\ s$$

To calculate the velocity v when the particle reaches ground, we apply

$$v = u + gt$$

$$v = 0 + 10 \times 6$$

$$= 60\ m/s$$

3. Height of the tower = 480 m

Initial velocity of the stone, $u = 0$

$g = 10\ m/s^2$

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

$u = 0$ in first part

So, $480 = \frac{1}{2} \times 10 \times t^2$

$480 = 5t^2$

$t = 9.8\ s$

Part 2 throwing stone $t = 1$ s less = 8.8 s

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

where $s = 480$, $t = 8.8$ (approx)

$480 = 8.8\ u + 5 \times 8.8^2$

$8.8u = 480 - 387$

$u = 10.5\ m/s$

4. a. Initial velocity of the stone = 0

Height, $h = 4.9$ m

$g = 9.8\ m/s^2$

Applying $h = ut + \frac{1}{2}gt^2$

$$= 0 \times t + \frac{1}{2} \times 9.8 \times t^2$$

$$4.9 = 4.9t^2$$

$$t = 1\ s$$

b. $v = u + gt$

$= 0 + 9.8(1)$

$= 9.8\ m/s$

c. Initial velocity of the stone = 0

Height, $h = 7.9$ m

$g = 9.8\ m/s^2$

$$v^2 - u^2 = 2\ gs$$

$$v^2 - 0 = 2 \times 9.8 \times 7.9$$

$$v^2 = 154.84$$

$$v = \sqrt{154.84}$$

$$v = 12.4\ m/s$$

d. $9.8\ m/s^2$

5. a. Height $h = 20$ m

Initial velocity = ?

Final velocity = 0

$g = 10\ m/s^2$

Applying $v^2 - u^2 = 2gh$

$$-u^2 = 2gh$$

$$-u^2 = 2(-10)(20)$$

$$u^2 = 400$$

$$u = 20\ m/s$$

b. Substituting the value of u in equation

$$v = u + gt$$

$$0 = 20 - (10)(t)$$

$$10\ t = 20$$

$$\therefore \quad t = 2\ s$$

6. The man is standing on top of a 60 m high tower. From the top of it, he throws a ball vertically upwards. So the starting point of the ball is 60 m high from the ground. Now to calculate the distance that the ball travels from the starting point to the top of the tower,

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

Initial velocity $u = 20$ m/s

Final velocity = 0

$$a = 10\ m/s^2$$

$$0 - (20)^2 = 2 \times (-10) \times s$$

$$-400 = -20s$$

$$s = 20\ m$$

Time taken to travel 20 m can be calculated by

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

$$20 = 20 \times t + \frac{1}{2} \times (-10) \cdot t^2$$

$$20 = 20\ t - 5t^2$$

or $\quad 4 = 4t - t^2$

Solving for t we get, $t = 2$ s.

Now the ball takes 2 s to reach the highest point.

To cross the man it has to travel 20 m down. So it would take another 2 s that is a total of 4 s to cross the man.

a. Now when the ball is at the minimum point from the ground

$$s = 80 \text{ m}$$
$$g = 10 \text{ m/s}$$
$$u = 0$$
$$s = ut + \frac{1}{2}gt^2$$
$$80 = \frac{1}{2}(10)(t^2)$$
$$t = 4 \text{ s}$$

b. Total time taken to reach the ground after release = 2 s + 4 s = 6 s

P. 115-116 Check Your Progress 4

A. Multiple-choice Questions

1. **c.** 100 : 1
2. **b.** 60 kg
3. **b.** beam balance
4. **c.** at the centre of the earth
5. **b.** 9.8 N
6. **b.** 20 N (since it will be 1/6th the weight of the body on earth).
7. **b.** 1/6
8. **b.** weight only

B. Very Short Answer Type Questions

1. Mass is the quantity of matter contained in a body. The SI unit of mass is kilogram.
2. The weight of body is the force with which it is attracted towards the centre of the earth. Its SI unit is newton.
3. **a.** The mass of an object is a measure of its inertia. The more the mass of a body, the harder it is to change the state of rest or of motion, i.e., a body with more mass needs a greater force to move it from rest or to stop its motion. The greater the mass of a body, the greater is its inertia.

   b. As the weight of an object is the force with which it is attracted towards the centre of the earth, its unit is same as that of force, i.e., newton.

   c. Since the weight of body is given by the product of its mass and acceleration due to gravity, the weight of a body changes from place to place. The value of g decreases with height. Due to this reason, a body weighs less on the mountains than at plains.

   d. A body contains the same quantity of matter irrespective of its location in the universe. Hence, the mass of an object is same everywhere. It does not change from place to place. It is constant.

   e. Weight is a vector quantity because it is the force with which it is attracted towards the centre of the earth. Since force is a vector, weight is also a vector quantity.

   f. Since the value of g is zero at the centre of the earth, the weight of a body is also zero at the centre of the earth since weight is given by the product of mass and acceleration due to gravity ($W = mg$).

C. Short Answer Type-I Questions

1. $W = mg$ implies, the weight of a body is given by the product of its mass and acceleration due to gravity.
2. Mass of the body = 20 kg

   $g = 10 \text{ m/s}^2$

   Weight $W = mg$

   $= 20 \times 10 = 200$ N
3. Weight of the body $W = 98$ N

   $g = 9.8 \text{ m/s}^2$

   Now, $w = m \times g$

   $98 = m \times 9.8$

   $m = 10$ kg
4. Mass of the man = 70 kg

   Value of g on moon = 1.6 m/s^2

   $$W = mg$$
   $$W = 70 \times 1.6$$
   $$= 112 \text{ N}$$

   Mass of the man on earth will remain the same.

D. Short Answer Type-II Questions

1. • Mass is a scalar quantity.
   • The mass of a body can never be zero.
   • Mass of an object is same everywhere in the universe.

2.

Parameter	Mass	Weight
Definition	The mass of a body is the quantity of matter contained in it.	The weight of a body is the force with which it is attracted towards the centre of the earth.
Physical quantity	It is a scalar quantity.	It is vector quantity.
Measurement	The mass of a body is measured by a physical balance.	The weight of a body is measured by a spring balance.
SI unit	The SI unit of mass is kg.	The SI unit of mass is newton.
Variation in value	The mass of a body is constant and does not change from place to place.	The mass of a body is not constant and does change from place to place.
Zero value	The mass of a body cannot be zero at anyplace.	The weight of a body becomes zero at the centre of the earth.
Nature	The mass of a body is the measure of its inertia.	The weight of a body is the gravitational force.

3. • Weight is a vector quantity.
   • Weight is measured by a spring balance.
   • Weight of a body changes from place to place since it depends on acceleration due to gravity.

4. Suppose a body of mass m and its weight on the moon is W_m (where W is the weight and m is the moon; which means weight on the moon). Mass of the moon is M and its radius is R.

Weight of an object on the moon = F (Force) with which the moon pulls

$$W_m = \frac{Gm}{R^2}$$

Weight of the same object on the earth is W_e (where W is the weight and e is the earth; which means weight on the earth).

Mass of the earth is 100 times of that of the moon.

Radius of the moon = R

Radius of the earth = $4R$

Weight of the object on the earth

$$W_e = \frac{G100m}{(4R)^2}$$

$$W_e = \frac{G100m}{16R^2}$$

$$\frac{W_m}{W_e} = \frac{Gm}{R^2} \div \frac{G100m}{16R^2}$$

$$= \frac{16}{100}$$

$$\frac{W_m}{W_e} = \frac{16}{100} = \frac{1}{6} \text{ (approx)}$$

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

5. Weight of the object on earth = 588 N

$g = 9.8 \text{ m/s}^2$

We know $W = mg$

$$588 = m \times 9.8$$

$$m = \frac{588}{9.8} = 60 \text{ kg}$$

Weight of the object on moon will be $\frac{1}{6}$th of that on earth.

Hence, weight of the object on moon = $\frac{588}{6}$ = 98 kg.

Substituting the value of weight and mass in the equation W = mg, we get

$$98 = 60 \times g$$

$$g = \frac{98}{60} = 1.633 \text{ m/s}^2$$

6. a. Mass of the object = 90 kg

Weight = $m \times g = 90 \times 10 = 900$ N

Weight of any object on moon = $\frac{1}{6}$th of that on earth.

Hence, weight of the object on moon

$$= \frac{1}{6} \times 900 = 150 \text{ N.}$$

b. Mass of the object will be the same anywhere in the universe.

Hence, the mass of the object on moon will also be 90 kg.

7. a. Weight of stone on earth = 490 N

Acceleration due to gravity $g = \frac{1}{2} \times 9.8 \text{ m/s}^2$
$= 4.9 \text{ m/s}^2$

We know $W = mg$

Substituting the value of W and g in the above equation, we get

$$490 = m \times 4.9$$

Therefore $m = 100$ kg

b. Since mass of the stone has been found to 100 kg. The weight of the stone on earth will be $m \times g$, i.e. $100 \times 9.8 = 980$ N

8. Since the mass of the heavenly body is twice that of earth and the radius is thrice that of earth, from the equation $g = G\frac{M}{R^2}$

It is clear that the value of g will increase by 2 and decrease by 9 in comparison to that of earth. So the value of $g = \frac{2}{9} \times 9.8$ (i)

Now weight of the body on earth = 450 N

Value of g on earth = 9.8 m/s^2

Applying $W = mg$

$$450 = m \times 9.8$$

$$m = \frac{450}{9.8}$$

Substituting the value of mass and g on the heavenly body from equation (i), we get

$$W = \frac{450}{9.8} \times \frac{2}{9} \times 9.8 = 100 \text{ N}$$

P.117 Higher Order Thinking Skills (HOTS) Questions

A. Multiple-choice Questions

1. **a.** have same velocities at any instant.
2. **c.** is least on equator
3. **c.** will move along a straight line tangential to the circular path
4. **c.** any two bodies having some mass
5. **a.** gravity.

B. Very Short Answer Type Questions

1. No change
2. It will become two times.

C. Short Answer Type-I Questions

1. The moon will move along a tangent to the earth at that point.
2. We know from the equation $g = G\frac{M}{R^2}$

   That the value of g is directly proportional to the mass and inversely proportional to the square of the radius. Now an increase of mass by 2 will lead to an increase in the value of g also by 2 and an increase in the radius by 2 will reduce the value of g by 4 times. The cumulative effect will be

$$\frac{2}{4} \times 9.8 = 4.9 \text{ m/s}^2$$

D. Short Answer Type-II Questions

1. The acceleration due to gravity will become one fourth that of earth, because $g \propto \frac{1}{R^2}$.
2. **a.** The force also increases by a factor of 3.

   b. Force of attraction increases by a factor of 4.

   c. Force increases by a factor of 9.

   d. Remains unchanged.

P.118-121 Exercises

A. Objective Type Questions

I. Multiple-choice Questions

1. **c.** size and shape of the objects
2. **d.** 6.67×10^{-7} N
3. **b.** 19.6 N
4. **b.** 78.4 m, 39.2 m/s
5. **b.** $g' > g$

I. Fill in the blanks

1. scalar
2. Zero
3. Maximum
4. Inertia
5. Weight

III. Assertion–Reasoning Type Questions

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

IV. Very Short Answer Type Questions

1. Consider earth to be a spherical body of mass M and radius R with centre O. Suppose a body of mass m be placed on the surface of the earth where acceleration due to gravity is g. Let F be the force of attraction between the body and the earth.

   According to Newton's Universal Law of Gravitation

$$F = G\frac{Mm}{R^2} \quad \text{(i)}$$

   This force exerted by earth produces acceleration in the body due to which the body moves downwards according to Newton's second law of motion.

Force = Mass × Acceleration

or, $F = ma$

The acceleration produced by the earth is known as acceleration due to gravity and represented by g. So, replacing a with g in the above equation, we get

$$F = mg \quad \text{(ii)}$$

Combining equations (i) and (ii), we get

$$mg = G\,\frac{Mm}{R^2}$$

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

2. All objects have tendency to fall towards the earth because the earth exerts a force on them that pulls them towards it.

3. Zero

4. Yes, a body can have mass even at the centre of the earth but no weight.

B. Short Answer Type-I Questions

1. No, it will not weigh the same. At Antarctica, its weight will be more because weight depends on the value of g and the value of g is more at the poles than at the equator as $g \propto \frac{1}{R^2}$.

2. The distance must be halved to maintain the force constant.

C. Short Answer Type-II Questions

1. If the density is same, then their masses will also be same. In that case since $g = \frac{Gm}{R^2}$,

Assuming the radii of the two planets to be R and $2R$ (since they are in 1 : 2 ratio), ratio of their acceleration due to gravity will be $\frac{Gm}{R^2} \div \frac{Gm}{(2R)^2}$

Hence, the acceleration due to gravity will be in 4 : 1 ratio.

2. Yes, the apple attracts the earth with an equal force but as the mass of earth is very large, it produces very small acceleration ($a \propto \frac{1}{m}$).

3. From the equation

$$g = \frac{GM}{R^2} \quad \text{(i)}$$

We know that g is directly proportional to the mass. Also from the equation $W = mg$, it is clear that the weight is directly proportional to the value of g. Hence, if the mass increases by 10%, the weight will also increase by 10%.

In the second part of the question, it is given that the radius of the earth becomes twice. Again from equation (i), we see an inverse proportionality between g and square of the radius. So if the radius is doubled, then the value of g will decrease and thereby the weight also will decrease by four times.

D. Long Answer Type Questions

1. Newton's Universal Law of Gravitation states that 'every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The force acts along the line joining the centres of the two bodies.'

Consider earth to be a spherical body of mass M and radius R with centre O. Suppose a body of mass m be placed on the surface of the earth where acceleration due to gravity is g. Let F be the force of attraction between the body and the earth.

According to Newton's Universal Law of Gravitation

$$F = G\,\frac{Mm}{R^2} \quad \text{(i)}$$

This force exerted by earth produces acceleration in the body due to which the body moves downwards according to Newton's second law of motion.

Force = Mass × Acceleration

or $F = ma$

The acceleration produced by the earth is known as acceleration due to gravity and represented by g. So, replacing a with g in the above equation, we get

$$F = mg \quad \text{(ii)}$$

Combining equations (i) and (ii), we get

$$mg = G\,\frac{Mm}{R^2}$$

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

where G = gravitational constant

$= 6.7 \times 10^{-11}$ N m^2/kg^2

M = Mass of the earth = 6×10^{24} kg

R = Radius of the earth = 6.4×10^{6} m

Substituting these values in the equation for g

$$g = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24}}{(6.4 \times 10^{6})^2} = 9.8 \text{ m/s}^2$$

The value of acceleration due to gravity on earth is 9.8 m/s^2.

2. Consider earth to be a spherical body of mass M and radius R with centre O. Suppose a body of mass m be placed on the surface of the earth where acceleration due to gravity is g. Let F be the force of attraction between the body and the earth.

According to Newton's Universal Law of Gravitation

$$F = G\frac{Mm}{R^2} \quad \text{(i)}$$

This force exerted by earth produces acceleration in the body due to which the body moves downwards according to Newton's second law of motion.

Force = Mass × Acceleration

or $F = ma$

The acceleration produced by the earth is known as acceleration due to gravity and represented by g. So, replacing a with g in the above equation, we get

$$F = mg \quad \text{(ii)}$$

Combining equations (i) and (ii), we get

$$mg = G\frac{Mm}{R^2}$$

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

a. We know

$$g \propto \frac{1}{R^2}$$

As we go up the surface of the earth, the distance form the centre of the earth increases and hence the value of g decreases, i.e. the value of g decreases with height.

b. We know

$$g \propto \frac{1}{R^2}$$

The radius of the earth is maximum near the equator, the value of g is minimum near the equator, and since the radius of the earth is minimum at poles, the value of g is maximum at the poles. The value of g increases as we go from the equator to the poles.

E. Numerical Problems

1. Mass of the object = 60 kg

Acceleration due to gravity g on earth = 10 m/s^2

We know, $W = mg$

Hence, weight of the object on earth = 60 × 10 = 600 N.

Since the weight of the object will be 1/6th of that on earth,

Weight of the object on moon = $\frac{1}{6}$ × 600 = 100 N

2. Height h = 5 m

Initial velocity = 0 (since it is dropped from a height)

Final velocity = ?

g = 10 m/s^2

Applying the equation $v^2 - u^2 = 2gh$

$$v^2 - 0 = 2 \times 10 \times 5$$
$$v^2 = 100$$
$$v = 10 \text{ m/s}$$

3. Height h = 100 m

Initial velocity = 0 (since it is dropped from a height)

Final velocity = ?

g = 10 m/s^2

Applying the equation $v^2 - u^2 = 2\,gh$

$$v^2 - 0 = 2 \times 10 \times 100$$
$$v^2 = 2000$$
$$v = \sqrt{2000}$$
$$v = 44.7 \text{ m/s}$$

4. Mass of the boy on earth = 30 kg

His mass on moon will also be 30 kg since mass does not change from place to place.

The weight of the boy on earth, $W = mg$ = 30 × 10 = 300 N.

Weight of the boy on moon will be $\frac{1}{6}$th of that on earth.

Therefore, his weight on moon = $\frac{1}{6}$ × 300 = 50 N

5. Weight of the man on moon = 130.4 kg

Acceleration due to gravity on moon = 1.63 m/s^2

$$W = mg$$
$$130.4 = m \times 1.63$$
$$m = \frac{130.4}{1.63} = 80 \text{ kg}$$

Now his weight on earth = $m \times g$ on earth
= 80 × 9.8 = 784 N

6. Initial velocity of the body u = ?

Maximum height reached by the body = 4.9 m

Final velocity v = 0

(since it stops after reaching maximum height).

Acceleration due to gravity g = – 9.8 m/s^2

(the body is thrown upwards)

We know

$$v^2 - u^2 = 2gh$$

or $$v^2 = u^2 + 2gh$$

$$0 = u^2 + 2 \times (-9.8) \times 4.9$$

$$u^2 = 96$$

$$u = \sqrt{96} = 9.8 \text{ m/s}$$

To calculate the time taken by the object to reach the maximum height, we apply

$$v = u + gt$$

$$0 = 9.8 - 9.8t$$

$$t = 1 \text{ s}$$

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. a. i. 13.3 s **b. i.** Heavier **c. ii.** 425 N
d. i. Zero **e. i.** 9.8 m/s^2

2. a. ii. u^2/2g **b.** 30.6 m
c. ii. 10 m/s **d. iii.** 16.8 m/s **e. i**

G. Value-Based Questions (Optional)

1. a. It is the gravitational force exerted by the sun and the moon on sea water leading to the formation of tides in the sea.

b. From sun, we learn that we should be kind and helpful to others. We should provide our fellow human beings all the necessary things.

2. a. We know $g = \dfrac{GM}{R^2}$

Value of acceleration due to gravity inversely depends upon the square of the radius of the earth. As we go on mountains the radius increases, therefore the value of acceleration due to gravity also decreases. Hence, the body weighs less on the mountains than at the plains.

b. The values learnt from Aradhya are that we should learn keenly and show interest in knowing the reason behind different phenomenons.

3. a. The mass of the quantity of matter in a body which remains same weather it is on earth or moon. It does not change from place to place. It is constant.

b. The values learnt from Yana are that we should stay active in classes and we should ask questions from the teachers to understand topics better.

CHAPTER – 4

FLOATATION

P.126-127 Check Your Progress 1

A. Multiple-choice Questions

1. **c.** thrust per unit area
2. **b.** pressure
3. **b.** should be decreased
4. **b.** inversely proportional
5. **c.** eight wheels

B. Very Short Answer Type Questions

1. The force acting on an object perpendicular to the surface is called thrust. The SI unit of thrust is newton.
2. Standing on loose sand makes our feet go deep into the sand. It is because the weight of our body which is a force acting vertically downwards. This is an example of force acting perpendicular to the surface of the sand.
3. The unit of pressure is newton per meter square or N/m^2. This unit has been given a specific name pascal in honour of the scientist Blaise Pascal.

   Pascal is a very small unit. The pressure is therefore expressed in kilopascal (kPa).

   1 kPa = 1000 Pa = 1000 $N/m^{2.}$
4. The thrust per unit area is called pressure.

   $$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

   a. Pressure is directly proportional to thrust.

   b. Pressure is inversely proportional to the area of contact.
5. **a.** Nails and pins have pointed tips. A small force on the head of the pin or nail will fall on a small area of the surface, thereby exerting considerable pressure to drive it into the surface easily.

   b. Tractors have broad tyres because due to broad tyres the area of contact between the tyres and ground is increased due to which the pressure exerted by the heavy truck on the ground is reduced.

   c. If the cutting edge of a knife is not sharpened or in other words blunt, the area of contact with the cutting surface increases. If area of contact increases, the pressure applied will be less and hence the given object cannot be cut easily.

   d. Flat shoes increase the area of contact between the shoes and the ground. That reduces pressure exerted on the ground thereby enabling one to walk on the ground without sinking in the mud.

   e. A broad strap of the bag increases the area of contact between the bag and shoulder thereby reducing the pressure exerted on the shoulder of the person.

C. Short Answer Type-I Questions

1. Take a conical wooden piece whose area of cross section at the broad end is about 5 cm^2 at the narrow end about 1 cm^2. Fill a tray with wet sand and place the wooden piece on the sand such that its broad end is in contact with the end. Gently place a 1 kg weight on the narrow end of the wooden piece. Now remove the wooden piece and measure the depression produced in sand with the help of a scale. Repeat the activity with the narrow end of the wooden piece. It will be found that the depression in case of the narrow end is more than that in case of broader end. Thus, the effect of forces of the same magnitude on different areas is different.
2. $\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$

   Pressure = ?

   Thrust = 100 N

   Area = 10 m^2

   $\text{Pressure} = \frac{100}{10}$

   Pressure = 10 Pa
3. $\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$

   Pressure = 200 Pa

   Area = 0.5 m^2

   $200 = \frac{\text{Thrust}}{0.5}$

   Force = 100 N
4. $\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$

   Pressure = 20 Pa

   Thrust = 200 N

   Area = ?

   $20 = \frac{200}{\text{Area}}$

   Area = 10 m^2

D. Short Answer Type-II Questions

1. **a.** Since thrust is a force, the SI unit of thrust is same as that of force, i.e. newton.

   b. Pressure is thrust per unit area. The unit of thrust is newton and the unit of area is square metre. The unit of pressure is therefore newton per metre square.

   c. Trucks carrying a heavy load are fitted with additional wheel because due to large number of wheels, the area of contact on the ground over which the weight of the heavy truck acts is increased. This reduces the pressure exerted by the heavy truck on the ground.

   d. The wheels of army tanks roll over a wide steel belt fitted wheels because due to the broad belt the area of contact on the ground over which the weight of the heavy truck acts is increased. This reduces the pressure exerted by the heavy tank on the ground.

2. Mass of the wooden block = 5 kg

   Acceleration due to gravity $g = 10\ \text{m/s}^2$

   Weight W = Thrust = $mg = 5 \times 10 = 50$ N

   a. When the block lies on its side dimensions 30 cm × 20 cm

   Thrust = 50 N

   Surface area of the block = Length × Breadth

   = 0.3 m × 0.2 m

   = $0.06\ \text{m}^2$

   $$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{50}{0.06} = 833.34\ \text{Pa}$$

   b. When the block lies on its side dimensions 30 cm × 5 cm

   Thrust = 50 N

   Surface area of the block = Length × Breadth

   = 0.3 m × 0.05 m

   = $0.015\ \text{m}^2$

   $$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{50}{0.015} = 3333.34\ \text{Pa}$$

P.132 Check Your Progress 2

A. Multiple-choice Questions

1. **c.** liquids and gases
2. **c.** both the base and the walls of the container
3. **b.** buoyant force
4. **a.** $h \rho g$.
5. **a.** increase

B. Very Short Answer Type Questions

1. Liquids and gases are regarded as fluids because they have no fixed shape and any substance which has no fixed shape and has the ability to flow is called a fluid.

2. Solids exert pressure on another surface on account of their weight whereas liquids exert pressure on the base and walls of the container in which they are enclosed.

3. Consider a body fully immersed in water. The water exerts pressure on all the surfaces of the body as well as on its top and bottom. The forces on top and bottom are equal and in opposite direction, so they cancel each other. We know pressure inside the liquid increases with depth. The lower surface of the cuboid is a greater depth than the surface, therefore it experiences a greater pressure. Therefore, the force acting on the lower surface in upward direction is greater in magnitude than the force that acts on the top surface in downward direction. Therefore, the resultant force acts in the upward direction. This force is called buoyant force.

4. The buoyant force due to a fluid on body immersed in it depends on four factors:

   i. the volume of the body submerged in the fluid.

   ii. the density of the fluid in which the body is submerged.

   iii. acceleration due to gravity.

   iv. temperature of the liquid.

5. The weight of an object is due to the earth's gravitational force which pulls the object in the downward direction. So, when an object is placed in air, only one force, i.e. downward force acts on it. So, when we lift an object lying in air, we have to apply an upward fore equal to the actual weight of the object. However, when the same object is lying in a liquid, then two forces act on it, i.e. the downward force of gravity and the upward buoyant force of the liquid. The force of gravity pulls the object downwards while the buoyant force of the liquid pushes the object upwards. So, when we lift an object immersed in liquid, we have to apply a smaller upward force because apart of the upward force required to lift the object is provided by the buoyant force of the liquid. Therefore, the object appears to be lighter as long as it is inside the liquid.

6. **a.** The weight of an object is due to the earth's gravitational force which pulls the object in the downward direction. So, when an

object is placed in air, only one force, i.e. downward force acts on it. So, when we lift an object lying in air, we have to apply an upward force equal to the actual weight of the object. However, when the same object is lying in a liquid, then two forces act on it, i.e. the downward force of gravity and the upward buoyant force of the liquid. The force of gravity pulls the object downwards while the buoyant force of the liquid pushes the object upwards. So, when we lift an object immersed in liquid, we have to apply a smaller upward force because apart of the upward force required to lift the object is provided by the buoyant force of the liquid. Therefore, the object appears to be lighter as long as it is inside the liquid.

b. Buoyant force is equal to weight of water displaced by the submerged object. Volume of water which will be displaced will be equal to the volume of the submerged object, and nothing to do with the density of submerged object. Though iron and wood differ in the densities, their volume is same. Hence, under water, both will experience the same buoyant force.

C. Short Answer Type-I Questions

1. When a body is partially or completely immersed in a fluid, it experiences an upthrust, which is equal to the weight of the fluid displaced by the immersed part of the body.
2. **a.** It is because the mug experiences a buoyant force equal to the weight of water displaced by it. Thus, the apparent weight of the mug is far less than its real weight. Hence, it can be lifted easily. As long as the mug of water is in air, only one force, downward force acts on it and to lift it we need to apply an upward force equal to its weight. Hence, it weighs more in air.

   b. The upthrust is more than the weight of the wooden block. Therefore, the wooden block rises when left under water and come to the surface.

D. Short Answer Type-II Questions

1. Take a cork and push it in water. On releasing the cork, immediately rises up to the surface. It appears that some upward force is exerted on the cork by water, which pushes the cork to the surface. If the cork is kept immersed, the fingers experience an upward force.
2. Consider a cylindrical body ABCD of height h and cross section area a, completely immersed in a liquid of density ρ. Let the upper surface AB of the body be at a depth h_1 below the free surface of the liquid, and the lower surface CD of the body be at a depth h_2 below the free surface of the liquid at depth h_1 the downward pressure on the upper surface AB is

$$p_1 = h_1\rho g$$

at depth h_2 the upward pressure on the upper lower surface CD is $p_2 = h_2\rho g$ as $h_2 > h_1$, $p_2 > p_1$ because we know that the pressure inside a liquid increases with depth.

Therefore, the net pressure P in the upward direction is

$$\begin{aligned} P &= p_2 - p_1 \\ &= h_2\rho g - h_1\rho g \\ &= (h_2 - h_1)\rho g \\ &= h\rho g \qquad (\therefore h_2 - h_1 = h) \end{aligned}$$

We know,

Force = Pressure × Area

$$\begin{aligned} \therefore \text{Upward thrust} &= h\rho g\, a \\ &= ah\rho g \\ &= V\rho\, g \end{aligned}$$

[$\therefore$ Volume (V) = Density (ρ) × Height (h)]

or upward thrust = $mg = W$.

Thus, upward thrust is defined as the weight of the liquid displaced by the immersed part of the body.

3. **a.** Weight of the body in air = 700 gf

   Weight of the body in water = 500 gf

   Loss of weight = 700 – 500 = 200 gf

   b. Loss of weight = The weight of liquid displaced = 200 gf

   $\therefore$ Buoyant force acting on the body = Loss of weight = 200 gf.

P.137-138 Check Your Progress 3

A. Multiple-choice Questions

1. **b.** sink in the liquid
2. **a.** float
3. **d.** none of these
4. **d.** 2.7 g/cm^3
5. **c.** maintain the same buoyant force

B. Very Short Answer Type Questions

1. Force of gravity and buoyant force.

2. a. When the weight of the body is equal or less than the buoyant force.
   b. When the weight of the body is greater than the buoyant force.
   c. Density of body is equal to density of water.
3. Density of a substance is its mass per unit volume.
   The relative density of a substance is defined as the ratio of density of the substance to density of water.
4. a. The body will sink in the liquid.
   b. The body will float just below the surface of the liquid.
   c. The body will float partially above the surface of the liquid.
5. The characteristics of a floating body are
   - The weight of the body is equal to the weight of the liquid displaced by the immersed part of the body.
   - In the floating position, the apparent weight of the body will be zero and the body will be in a weightless condition.
6. a. The relative density of iron is 7.8 and since it is greater than 1, it is heavier than water, hence and iron nail sinks in water. Whereas the relative density of mercury is 13.6. Since the relative density of iron is less than that of mercury, the iron nail floats in water.
   b. The density of salt water is more. Hence, the egg shell sinks in fresh water but floats in salt water.

C. Short Answer Type-I Questions

1. When any body displaces a weight of water equal to its own weight, it floats. This is called as principle of floatation.
2. Density of a substance is defined as its mass per unit volume. Its SI unit is kg/m^3.
3. The relative density is defined as the ratio of the density of the substance to the density of water at 4°C. It has no unit. It is a pure number.
4. That the relative density of iron is 7.8 means that it is heavier than water and thus will sink in water.

D. Short Answer Type-II Questions

1. a. The density of iron is greater than that of water. When an iron nail is placed in water, the weight of the nail is greater than the weight of water displaced by it, so it sinks. On the other hand, a ship is made hollow from inside which reduces the average density of ship than that of water. So, a ship floats on water.
   b. The density of river water is less than that of sea water. Thus, in fresh water or river water, the ship sinks to a greater depth. The density of salt water is high and thus the ship floats on the surface being lighter than the sea water.
   c. Hydrogen gas is lighter than air. When a balloon is filled with hydrogen, the weight of the air displaced by the inflated balloon becomes more than the weight of the balloon. Since the upthrust on the balloon is more than its weight, it experiences a net upward force and hence it rises up.
2. Mass of the object = 40 g
   Volume = 80 cm^3
   Density = $\frac{40}{80}$ = 0.5 g/cm^3
   Yes, the object will float in water because its density is less than that of water.
3. Its density in SI unit is 13.6×10^3 kg/m^3

P.138-139 Higher Order Thinking Skills (HOTS) Questions

A. Multiple-choice Questions

1. d. $d_1 < d_2 < d_3$
2. a. 2 N
3. c. The pressure exerted is maximum when the breadth and height of the block form the base.
4. c. Both the base and the walls of the container.
5. a. normal

B. Very Short Answer Type Questions

1. Upthrust
2. Making area half

C. Short Answer Type-I Questions

1. Skiers use long flat skis because doing so increases the area of contact with the snow which reduces the pressure exerted by the skier on the snow, enabling them to slide over snow without sinking.
2. Upthrust is given by the equation, upthrust = $V\rho g$, where V is the volume, ρ is the density and g is the acceleration due to gravity. Upthrust shares a direct proportionality with both volume of the body and density of the liquid.

a. When the volume increases, the upthrust will also increase.

b. When the density of the liquid decreases, the upthrust will also decrease.

D. Short Answer Type-II Questions

1. The chances of drowning in dead sea is very less because it is highly saline and hence will have very high density. The density of human body will be lower than that of sea water in dead sea and hence will float.

2. a. Sea water is salt water whereas river water is fresh water. Salt water will have higher density than fresh water. So it is easier to swim in sea water because less effort is needed to keep the body floating on the surface due to higher density of salt water.

   b. A body experiences more buoyant force on earth than on moon because the acceleration due to gravity on earth is more than that on the moon. The buoyant force is directly proportional to the acceleration due to gravity.

P. 139-142 Exercises

A. Objective Type Questions

I. Multiple-choice Questions

1. c. C
2. b. $W_1 = W_2$
3. c. pressure increases with depth.
4. d. All the above readings have to be taken

II. Fill in the blanks

1. Force
2. depth, density
3. Pressure
4. kg m^{-3}
5. Relative density

III. Assertion–Reasoning Type Questions

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

IV. Very Short Answer Type Questions

1. Volume of the solid and density of the liquid.
2. Relative density of gold is 19.3 means that gold is heavier than water and thus will sink in water.

B. Short Answer Type-I Questions

1. Tractors have broad tyres because due to broad tyres the area of contact between the tyres and ground is increased due to which the pressure exerted by the heavy truck on the ground is reduced.
2. Due to wide foundations, the area over which the weight of the building acts is increased. This reduces the pressure exerted by the building on the ground. So the multi-storied buildings do not sink in ground.
3. The cork rises to the surface when released under water because of the buoyant force. Hence, it must be pushed in to keep it inside water.

C. Short Answer Type-II Questions

1. The applications of Archimedes principle are:
   - Archimedes principle is used in designing ships and submarines.
   - Archimedes principle is used to determine the relative density of substance.
   - The hydrometers used for determining densities of liquid are based on Archimede's principle. They are also used to find the relative density of a liquid directly without any calculation.
   - Lactometers which are used to determine the purity of a sample of milk are based on Archimedes principle. A lactometer measures the relative density of milk. Addition of water in milk reduces the density of milk.
2. Relative density is the ratio of density of any substance to the density of water. If the relative density of a substance is more than 1, it is denser than water and thus will sink in water. If the relative density is less than 1 (1 is the density of water 1 g/cm^3) it will be lighter than water and will float on it.

D. Long Answer Type Question

1. Consider a beaker filled with a liquid of density *d*. Imagine a cylindrical column of liquid with an area of cross section *a* at level *B* at a depth *h* below the surface of the liquid.

   Volume of the imaginary column of liquid $v = a \times h$

   Thrust at the base of the cylindrical column of liquid = Weight of the liquid column

   = mass of the liquid column × g

   $= m \times g$

   $= (V \times d) \times g$

   (since mass $m = V \times d$)

   Thrust $= (a \times h) \times d \times g$

   We know, Pressure $= \dfrac{\text{Thrust}}{\text{Area}}$

$$= \frac{a \times h \times d \times g}{a} = hdg$$

E. Numerical Problems

1. Force = 200 N

   Area = 10 m^2

   Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{200}{10} = 20$ Pa

2. Weight of the body in air w_1 = 600 gf

   Weight of the body in water w_2 = 450 gf

   a. Apparent loss in weight = $w_1 - w_2$ = 600 – 450 = 150 gf

   b. Upthrust on the body = Loss in weight of the body = 150 gf

   c. Volume of the body = Volume displaced = 150 cm^3

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. a. i. about 10,900 km. **b. iii.** 0.7

c. ii. mercury **d. iii.** C

e. i. the western Pacific Ocean.

2. a. ii. Maharashtra

b. iii. No, at the bottom of the wall

c. ii. 294 kPa

d. iii. 1.83×10^{10} N

e. ii. 58.8 N

G. Value-Based Questions

1. a. Cutting edges of knives are sharpened to decrease the area of contact between the knife and the object to be cut. A small force when applied on sharp knives will exert a large pressure which helps to cut given object easily.

b. The values we learn from Pooja are that we should be kind and helpful. We should help people who are in need.

2. a. Skiers use long flat skis because doing so increases the area of contact with the snow which reduces the pressure exerted by the skier on the snow, enabling them to slide over snow without sinking.

b. We learn that we should help others whenever needed. We should share our personal belongings with our friends and help them.

3. a. The density of iron sheet is greater than that of water. Therefore, if we place a iron sheet on the surface of water, it sinks. On the other hand, a ship made of same iron sheet does not sink because it is made hollow from inside which causes the average density of the sheet to become less than that of water. So, a ship floats on water.

b. The values we learn from Prabha are that we should help others and learn new things keenly and then apply them in real life efficiently.

4. a. Hydrogen gas is lighter than air. When a balloon is filled with hydrogen the weight of air displaced by the inflated balloon becomes more than the weight of the balloon. Since the upthrust on the balloon is more than its weight, it experiences a net upward force and hence it rises up.

b. We learn that we should help people and make sure that we make the people around us happy with our deeds. We should also care about others.

CHAPTER – 5

WORK AND ENERGY

P.147-148 CHECK YOUR PROGRESS 1

A. Multiple-choice Questions

1. **c.** force × displacement
2. **b.** it gains energy
3. **b.** joule
4. **d.** zero
5. **b.** engine pulling a train
6. **a.** increases
7. **c.** 1 newton metre
8. **c.** weight of the body × vertical distance moved

B. Very Short Answer Type Questions

1. Work is said to be done when the force acting on a body produces motion in it, in the direction of force applied.
2. Work is a scalar quantity.
3. The SI unit of work is joule.
4. **a.** Work is done. The gravitational force of earth causes the apple to fall.

   b. Work is done. The force exerted by the girl makes the book move in the direction of force applied.

   c. Work is done. The force exerted by the horse makes the cart move in the direction of force applied.

   d. No work is done. Reading a book is a mental activity. In terms of physics there is no work done.

   e. No work is done. Pushing the wall does not move it. Since there is no displacement produced by the force.

   f. Work is not done. Man holding a bucket of water exerts an upward force equal to the weight of the bucket acting downwards but there is no displacement produced.

   g. No work is done. The porter holding weight on his head does not produce any displacement.

   h. Work is done. The air exerts a force on the kite and makes it move.

   i. Work is done. The man covers the distance with time while taking the stairs. Since there is displacement, work is done.

   j. Work is done. The force exerted on the ball makes it move against gravity.

C. Short Answer Type-I Questions

1. Amount of work done depends on the magnitude of force applied and the displacement of the body.
2. Force applied = 40 N

   Displacement = 5 m

   Work done = Force × Displacement = 40 × 5

   = 200 J
3. Work done = 160 J

   Force applied = 20 N

   Work done = Force × Displacement

   160 = 20 × Displacement

   Displacement = 8 m (in the direction of force applied)
4. Mass = 50 kg

   Displacement = 72 m

   $g = 10\ m/s^2$

   $W = m \times g \times h$

   $W = 50 \times 10 \times 72 = 36000$ J

   If we take g as 9.8 m/s^2, we will get 35280 J.
5. Force applied = 100 N

   Displacement = 50 m

   Work done = Force × Displacement = 100 × 50

   = 5000 J

D. Short Answer Type-II Questions

1. When a force F acting on a body produces a displacement s in it, in the direction of the force, the work done W by this force is the product of force and displacement, i.e.

   Work done = Force × Displacement
2. Mass of the car = 1000 kg

   Initial velocity = 30 m/s

   Final velocity = 0 (since it comes to rest after application of brakes)

   Distance travelled = 50 m

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

   $0 - (30)^2 = 2 \times a \times 50$

   $a = -9\ m/s^2$

   The negative sign indicates retardation.

   Substituting the value of acceleration in the equation $F = ma$

   $F = 1000 \times 9 = 9000$ N

   Work done = Force × Displacement

   = 9000 × 50

   = 4.5×10^5 J

3. Work done = 8000 J

Mass = 100 kg

g = 10 m/s^2

Work done in lifting an object against gravity

$= m \times g \times h$

$8000 = 100 \times 10 \times h$

$h = 8$ m

4. Mass = 1000 kg

Displacement = 50 m

g = 10 m/s^2

$W = m \times g \times h$

$W = 1000 \times 10 \times 50 = 5,00,000$ J

5. Work done, W = 10,000 J

Vertical height = 10 m

$W = m \times g \times h$

$10000 = m \times 10 \times 10$

$m = 100$ kg

Weight = Mass × Acceleration due to gravity

= 100 × 10 = 1000 N

P.153-154 Check Your Progress 2

A. Multiple-choice Questions

1. **d.** 0 J
2. **c.** zero
3. **c.** no work is done
4. **a.** 0°
5. **d.** 90°
6. **d.** 180°
7. **c.** negative

B. Very Short Answer Type Questions

1. **a.** positive. The body moves in the direction of applied force.

   b. positive. String moves in the direction of applied force.

   c. positive. The motion is in the direction of gravitational force.

   d. negative. The motion of the ball is against gravity.

   e. positive. Motion of the body is in the direction of applied force.

   f. positive. The motion of the bucket is in the direction of applied force.

   g. negative. Work done by gravity on a body moving upwards is negative.

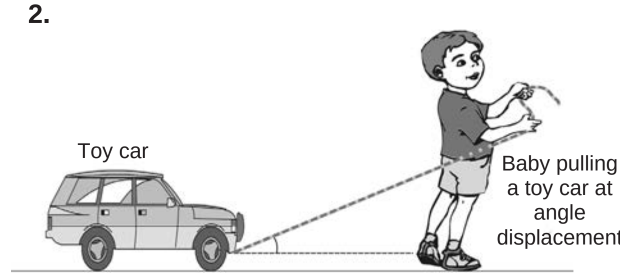
   h. negative. Work done by frictional force is negative.

   i. positive. The body moves in the direction of applied force. But the work done by frictional force is negative.

   j. zero.

C. Short Answer Type-I Questions

1. When the angle between the direction of force and the direction of displacement is 90°, then cos θ = cos 90° = 0. Hence, work done is zero. For example, a potter carrying a load on his head moves on a horizontal platform and a body moving in a circular path.

2. 

A baby pulling a toy car at an angle

   a. The toy moves in the horizontal direction.

   b. The force applied is at an angle along the string.

D. Short Answer Type-II Questions

1. When a force F acting on a body produces displacement s in it, in the direction of the force, the work done W by this force is product of the force and displacement., i.e.

   Work done = Force × Displacement

   $W = F \times s$

2. Mathematically, force (which causes the motion) is equal to $F \cos \theta$ where F if the force and θ is the angle between the force applied and the direction of motion. Thus, work done is

   $W = F \cos \theta \times s$

   where W = work done

   F = force applied

   θ = angle between the direction of the force and the direction of motion

   s = displacement.

3. When the angle between the direction of force and the direction of displacement is acute ($\theta < 90°$), then cos θ is positive. Hence, work done is positive. Work done when the body moves in the direction of the applied force is positive. For example, a body falling freely

under gravity and when a lawn mover is pushed by applying a force along the handle at an acute angle.

4. When the angle between the direction of force and the direction of displacement is obtuse ($\theta > 90°$), then cos θ is negative. Hence, work done is negative. For example, body moving against gravity and work done by frictional force on a body moving on a rough horizontal surface.

P.160-161 Check Your Progress 3

A. Multiple-choice Questions

1. **c.** the amount of work it can do.
2. **b.** 20 J
3. **a.** tripled
4. **d.** decreases 25 times
5. **c.** eight times

B. Very Short Answer Type Questions

1. Coal, kerosene, cooking oil and wood have chemical energy stored in them.
2. Sound is a form of energy. A vibrating body possesses sound energy. Sound as a form of energy is experienced when doors and windows shatter due to an explosion or a loud sound produced by a low flying plane.
3. Electric cell
4. Magnetic energy can be used to separate scrap iron from a heap of waste materials by using electromagnets and also to produce magnetic field.
5. Energy of a body is defined as the capacity or ability of the body to do work.
6. Energy is a scalar quantity.
7. Sunlight drives photosynthesis.
8. 1 J is the energy required or consumed to do 1 J of work.
9. The energy possessed by a body by virtue of its motion is called kinetic energy. Its SI unit is joule.
10. Heat energy
11. Nuclear energy
12. Energy and amount of work done are directly related. More the energy, more is the amount of work done.
13. Different forms of energy are chemical energy, sound energy, light energy, electrical energy, heat energy, magnetic energy, mechanical energy and nuclear energy.

C. Short Answer Type-I Questions

1. When a cricket ball hits the stationary stumps at a fast speed, the stumps are blown away. The moving cricket ball has the capacity to blow the stumps away. In other words the energy possessed by the moving cricket ball could do work by displacing the cricket stumps.
2. The SI unit of energy is joule. The energy possessed by an object is measured in terms of capability of an object to do work. The unit of energy is thus same as that of work, hence the unit of energy is also joule.
3. **a.** When a cricket ball hits the stationary stumps at a fast speed, the stumps are blown away. The moving cricket ball has the capacity to blow the stumps away. In other words the energy possessed by the moving cricket ball could do work by displacing the cricket stumps.

   b. If a hammer is raised vertically above the head of a nail and allowed to fall on the head of the nail, it will do work in driving the nail into the wood. Spring in toy car does work when it comes back to its original state from the coiled condition when wound using a key. This makes the toy car move on the ground.
4. Mass of the body = 2 kg

   Velocity = 0.2 m/s

   Kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times (0.2)^2 = 0.04$ J
5. Since kinetic energy is proportional to the square of velocity, an increase in velocity by three times will increase the kinetic energy by (3^2), i.e. nine times.
6. Mass of the bullet = 50 g = 0.05 kg

   Velocity of the bullet = 400 m/s

   Kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 0.05 \times (400)^2$

   $= 4000$ J
7. Doubling the velocity because kinetic energy is proportional to the square of velocity.

D. Short Answer Type-II Questions

1. **a.** When a cricket ball hits the stationary stumps at a fast speed, the stumps are blown away. The moving cricket ball has the capacity to blow the stumps away. In other words, the energy possessed by the moving cricket ball could do work by displacing the cricket stumps.

b. If a hammer is raised vertically above the head of a nail and allowed to fall on the head of the nail, it will do work in driving the nail into the wood.

c. Spring in toy car does work when it comes back to its original state from the coiled condition when wound using a key. This makes the toy car move on the ground.

2. Consider a body of mass m moving in a straight line with a velocity v. Suppose initially a body is at rest. Let force F be applied on the body till it attains a velocity v starting from rest. Let the acceleration produced in the body be a and the distance moved by the body as it attains this velocity v be s.

From the equation of motion

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

$$v^2 - 0 = 2as \ (\because u = 0)$$

or $$v^2 = 2as$$

$$s = \frac{v^2}{2a}$$

According to Newton's second law of motion, the force applied on the body

$$F = ma$$

The work done by this force on the body is given by

$$\text{Work} = \text{Force} \times \text{Distance}$$
$$= F \times s$$

$$\therefore \quad \text{Work} = ma \times \frac{v^2}{2a}$$

$$\text{Work} = \frac{1}{2}mv^2$$

$$\therefore \text{Kinetic energy} = \frac{1}{2}mv^2$$

3. Kinetic energy = 750 J

Mass of the man = 60 kg

We know kinetic energy = $\frac{1}{2}mv^2$

or $$750 = \frac{1}{2} \times 60 \times (v)^2$$

or $$(v)^2 = 25$$

$$v = 5 \text{ m/s}$$

4. Kinetic energy = 625 J

Mass of the man = 50 kg

We know, kinetic energy = $\frac{1}{2}mv^2$

or $$625 = \frac{1}{2} \times 50 \times (v)^2$$

or $$(v)^2 = 25$$

$$v = 5 \text{ m/s}$$

5. Initial velocity = 0

Final velocity = v

Height = 5 m

Applying $v^2 - u^2 = 2 \times g \times s$

$$v^2 - 0 = 2 \times 10 \times 5$$

$$v = 10 \text{ m/s}$$

Speed just before it hits the ground will be 10 m/s.

Kinetic energy = $\frac{1}{2}mv^2$

Substituting the value of v in the above equation,

Kinetic energy = $\frac{1}{2} \times 10 \times (10)^2 = 500$ J

6. Mass of the truck = 5000 kg

Velocity = 40 m/s

Kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 5000 \times (40)^2$

$$= 4 \times 10^6 \text{ J}$$

7. Mass of the bullet = 50 g = 0.05 kg

Velocity = 500 m/s

Kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 0.05 \times (500)^2 = 6250$ J

The distance travelled by the bullet = 10 cm = 0.1 m

Applying $v^2 - u^2 = 2 \times a \times s$

$$v^2 - 0 = 2 \times a \times 0.1$$

$$0 - (500)^2 = 2 \times a \times 0.1$$

$$-250000 = 0.2a$$

$$a = -1250000 \text{ m/s}^2$$

Substituting the value of acceleration in the equation $F = ma$

$$F = 0.05 \times -1250000 = -62500 \text{ N}$$

P.164-165 CHECK YOUR PROGRESS 4

A. Multiple-choice Questions

1. **c.** potential energy
2. **b.** potential energy
3. **d.** potential energy
4. **b.** increase
5. **c.** elastic potential energy

B. Very Short Answer Type Questions

1. The potential energy of a body is defined as the energy possessed by the body by virtue of its position or configuration. Its SI unit is joule.

2. Consider a ball placed on a spring. The ball remains in the state of rest. Compress the spring. Now if the spring is released, it pushes the ball. Thus, this shows that a compressed spring has the ability to do work.
3. Consider a block attached to a spring. The block remains in the state of rest. Let the spring be stretched and released. The stretched spring contracts and while contracting pulls the block with it. The contracting spring has the ability to do work.
4. Take a wooden block and fix a nail on it. Now gently place a stone on the head of the nail. The nail does not move. But when the stone is raised to a certain height and dropped on the nail, the nail moves in. This shows that, the stone has acquired some energy.
5. The gravitational potential energy of an object at a point above the ground is defined as the work done in raising it from the ground to that point against gravity. For example, water stored at a height in a dam or reservoir possesses gravitational potential energy.
6. Elastic potential energy of a body is the energy possessed by the body by virtue of its configuration. For example, energy stored in a compressed spring.
7. a. Potential energy also gets tripled.
   b. Potential energy is also reduced by one fourth.
   c. Potential energy increases by four times.
   d. Potential energy is reduced to half.
   e. Potential energy gets reduced.

C. Short Answer Type-I Questions

1. a. When we wind the spring of our watch, some work is done on the spring and it gets coiled more tightly. This work gets stored up in the compressed spring in the form of elastic potential energy. As the spring unwinds, it works to move the hands of the watch.
   b. When a bow is stretched, there is change of configuration of its different parts. Work done on the bow during stretching is stored in the bow as elastic potential energy. When this stretched bow is released, the arrow moves forward with a greater velocity on account of the potential energy of the stretched bow, which is imparted to the arrow.

2. Mass of the book = 0.5 kg
   Potential energy = 1 J
   $g = 10\ m/s^2$
   Potential energy = mgh
   $1 = 0.5 \times 10 \times h$
   $h = 0.2$ m
3. Mass = 200 kg
   Potential energy = 9800 J
   $g = 9.8\ m/s^2$
   Potential energy = $200 \times 9.8 \times h$
   $9800 = 200 \times 9.8 \times h$
   $$h = \frac{9800}{200 \times 9.8}$$
   $h = 5$ m
4. Potential energy = 4900 J
   Mass = 50 kg
   Potential energy = mgh
   $4900 = 50 \times 9.8 \times h$
   $h = 10$ m

D. Short Answer Type-II Questions

1. Mass of the boy = 50 kg
   Vertical height = 100 m
   $g = 10\ m/s^2$
   Potential energy = mgh
   $= 50 \times 10 \times 100$
   $= 50{,}000$ J
   The energy acquire by him is also 50,000 J
   Work done = Change in energy
   = 50,000 J
2. Mass of the boy = 50 kg
   Height = 30 × 20 cm = 600 cm = 6 m
   $g = 10\ m/s^2$
   Potential energy = $50 \times 10 \times 6$
   = 3000 J
3. Mass of the object = 1 kg
   Potential energy = 20 J
   $g = 10\ m/s^2$
   Potential energy = mgh
   $20 = 1 \times 10 \times h$
   $h = 2$ m
4. Mass of the rocket = 3×10^6 kg
   Height = 25 km = 25000 m
   $g = 10\ m/s^2$
   Potential energy = $3 \times 10^6 \times 10 \times 25000$
   $= 7.5 \times 10^{11}$ J

P.171-172 CHECK YOUR PROGRESS 5

A. Multiple-choice Questions

1. **b.** chemical energy
2. **a.** mechanical energy to electrical energy
3. **b.** photoelectric cell
4. **c.** only potential energy
5. **c.** kinetic energy increases

B. Very Short Answer Type Questions

1. The change of one form of energy into another form of energy is known as transformation of energy. Example: Light energy is converted to electrical energy by a photo-electric cell.
2. **a.** Heat energy to electrical energy
   b. Electrical energy to heat energy
   c. Magnetic energy to mechanical energy
   d. Sound energy to electrical energy
   e. Chemical energy to electrical energy
   f. Heat energy to mechanical energy
3. **a.** Steam engine
   b. Solar cell
   c. Electric bulb
   d. Shattering of glass
   e. Burning of fuels
   f. Nuclear reactor

C. Short Answer Type-I Questions

1. **a.** Electrical energy to magnetic energy
   b. Mechanical energy to electrical energy
   c. Sound energy to electrical energy
   d. Light energy to electrical energy
2. Fan, tape recorder, air cooler, computer and bore well.
3. Energy can neither be created nor destroyed. It can only be converted from one form to another. The total energy before and after the transformation remains the same. For example, the law of conservation of energy in a simple pendulum. A simple pendulum consists of a metal ball suspended by a long thread. It swings back and forth about its mean position. When the pendulum is at the extreme positions, it has only potential energy but no kinetic energy. As it starts moving down, towards the mean position, its potential energy decreases and the kinetic energy increases. When bob reaches the mean position, it has no potential energy but has only kinetic energy. This is how energy get converted from one form to another but can neither be created or destroyed.

D. Short Answer Type-II Questions

1. **a.** Rubbing two pieces of stones generates heat.
   b. Telephone
   c. Production of sound by vibration.
   d. Decomposition of silver salts in photographic plate.
   e. Loudspeaker
   f. Electric bulbs
   g. Generation of electricity by dynamo.
2. When a ball is thrown up in the air, it acquires a kinetic energy as it moves upwards. After reaching the highest point it possesses potential energy alone and while coming down, it acquires kinetic energy. After reaching the ground it possesses kinetic energy alone.
3. $m = 10$ kg

   $h = 20$ m

   $g = 10$ m/s^2

   a. Potential energy = mgh

   Kinetic energy = $\frac{1}{2}mv^2$

   $h = 20$ m

   Potential energy = $10 \times 10 \times 20$

   = 2000 J

   Kinetic energy = $\frac{1}{2} \times 10 \times 0$ $(v = 0)$

   = 0

   b. $h = 15$ m

   Potential energy = $10 \times 10 \times 15$

   = 1500 J

   $v^2 = u^2 + 2gh$

   $v^2 = 0 + 2 \times 10 \times 5$

   = 100

   Kinetic energy = $\frac{1}{2} \times 10 \times 100$

   = 500 J

   c. $h = 10$ m

   Potential energy = $10 \times 10 \times 10$

   = 1000 J

   $v^2 = u^2 + 2gh$

   $v^2 = 0 + 2 \times 10 \times 10$

$v^2 = 200$

$v = \sqrt{200}$ m/s

Kinetic energy = $\frac{1}{2} \times 10 \times 200$

= 100 J

d. h = 8 m

Potential energy = 10 × 10 × 5

= 500 J

$v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 10 \times 15$

$v^2 = 300$

$v = \sqrt{300}$ m/s

Kinetic energy = $\frac{1}{2} \times 10 \times 300 = 1500$ J

e. Just above the ground

Potential energy = 10 × 10 × 0 = 0 J

$v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 10 \times 20$

$v^2 = 400$

v = 20 m/s

Kinetic energy = $\frac{1}{2} \times 10 \times 400$

= 2000 J

The sum of potential energy and kinetic energy at every point is a constant. This shows that energy can get converted from one form to another but can neither be created nor be destroyed. Hence, the data verifies the law of conservation of energy.

P.175-176 Check Your Progress 6

A. Multiple-choice Questions

1. **a.** labourer A
2. **a.** scalar quantity
3. **c.** 746 watts
4. **d.** kilowatt hour
5. **b.** 3.6×10^6 J

B. Very Short Answer Type Questions

1. Power is the ratio of energy to time, both being scalar quantities, power is also a scalar quantity.
2. The rate of doing work by a body is called power. The SI unit of power is watt.
3. The rate of energy supplied by a body is called power.
4. SI unit of electrical energy is joule.
5. **a.** Kilowatt is the unit of power.

   b. Kilowatt hour is the unit of electrical energy.
6. Power depends on the amount of work done and time taken.
7. Consider an ox ploughing a field. An ox may not always perform the same amount of work. Thus, there is a term as average power which is the average amount of work done by a body per unit time.

C. Short Answer Type-I Questions

1. The SI unit of electrical energy is joule and the commercial unit of energy is kilowatt hour.

   1 kWh = 1 kW × 1 h

   = 1000 W × 60 × 60 s

   (since 1 kW = 1000 W, 1 h = 60 × 60)

   1 kWh = 3600000 J

   1 kWh = 3.6×10^6 J
2. The SI unit of electrical energy is joule but it is too small and inconvenient to express large quantity of energy. So, for commercial purposes a bigger unit of electrical energy kilowatt hour is used.
3. One kilowatt hour is the amount of electrical energy consumed by an electrical appliance of power 1 kilowatt in one hour.

   The electricity bill shows the electrical energy consumed in terms of units of electricity. The bill is calculated by multiplying the number of units with the cost of one unit.
4. Mass = 50 kg

   Distance covered = 25 m

   $g = 10$ m/s^2

   Work done = Force × Distance

   = (Mass × Acceleration) × Distance

   = 50 × 10 × 25 = 12500 J

   Time taken = 5 s

   Power = $\frac{E}{t} = \frac{12500}{5}$ = 2500 W
5. Mass = 100 kg

   Distance covered = 19 m

   $g = 10$ m/s^2

   Work done = Force × Distance

   = (Mass × Acceleration) × Distance

   = 100 × 10 × 19 = 19000 J

   Time taken = 25 s

Power = $\frac{E}{t} = \frac{19000}{25}$ = 760 W

D. Short Answer Type-II Questions

1. Mass of the boy = 50 kg

Distance covered = 60 × 0.15 = 9 m

g = 10 m/s^2

Work done = Force × Distance

= (Mass × Acceleration) × Distance

= 50 × 10 × 9 = 4500 J

Time taken = 9 s

Power = $\frac{E}{t} = \frac{4500}{9}$ = 500 W

2. Mass of the boy = 40 kg

Distance covered = 15 × 0.15 m = 2.25 m

g = 10 m/s^2

Work done = Force × Distance

= (Mass × Acceleration) × Distance

= 40 × 10 × 2.25 = 900 J

Time taken = 10 s

Power = $\frac{E}{t} = \frac{900}{10}$ = 90 W

3. Mass = 25 kg

Distance covered = 10 m

g = 10 m/s^2

Work done = Force × Distance

= (Mass × Acceleration) × Distance

= 25 × 10 × 10 = 2500 J

Time taken = 50 s

Power = $\frac{E}{t} = \frac{2500}{50}$ = 50 W

4. Power of the electric bulb = 100 W

Time = 20 × 60 × 60 s = 72000 s

Power = $\frac{E}{t}$

100 W = $\frac{E}{72000}$

$E = 7.2 \times 10^6$ J

Number of units = $\frac{7.2 \times 10^6}{3.6 \times 10^6}$ kWh = 2 units

Each unit cost 4 rupees. Hence, the bill would be 2 × 4 = ₹ 8.

5. Power of the electric bulb = 60 W

Time = 10 × 60 × 60 s = 36000 s

Power = $\frac{E}{t}$

60 W = $\frac{E}{36000}$

$E = 2160000 = 2.16 \times 10^6$ J

P. 176-177 Higher Order Thinking Skills (HOTS) Questions

A. Multiple-choice Questions

1. **c.** remains constant
2. **d.** 180°
3. **d.** zero
4. **c.** kilowatt
5. **c.** half potential and half kinetic energy

B. Very Short Answer Type Questions

1. When the velocity becomes three times the original velocity, the kinetic energy becomes nine times.
2. Doubling the speed because the kinetic energy is directly proportional to the square of the velocity.
3. 0°
4. The moon moves around the earth in a circular path. The gravitational force of the earth is the centripetal force. Then at every point of the circular orbit, centripetal force acts on the satellite at right angles to the direction of the motion of satellite, i.e. θ = 90°, we know, $W = Fs \cos \theta = Fs \times 0 = 0$.

C. Short Answer Type-I Questions

1. The person applies a force on the load in the upward direction but there is no displacement of the load. Hence, the work done is zero. The person may be exhausted by the weight and strain.
2. **a.** Amount of work done also increases.

   b. If the displacement is reduced the work done also decreases.

D. Short Answer Type-II Questions

1. Yes. A body can possess energy even when it is not in motion. Energy possessed by an object by virtue of its position is called potential energy. For example, water stored in a dam.
2. Since kinetic energy = $\frac{1}{2}mv^2$.

   Increase in mass by two times increases the kinetic energy also by two times. However, the kinetic energy is inversely proportional to the square of velocity. Hence, reduction of velocity by half reduces the kinetic energy by four times. The overall effect of doubling and reduction by four times is reduction of the kinetic energy by half.

3. Initially when the truck is at rest, all its energy is potential energy. When it starts by burning the fuel, its chemical energy of the fuel is converted into mechanical energy and it acquires kinetic energy and starts moving.

4. **a.** Due to the potential energy of the compressed spring in a loaded pistol, the bullet is released with a great velocity on firing the pistol.

   b. By winding the key of a toy car, we wind the spring. On winding the spring gets coiled more tightly. The work done in winding the spring gets stored up in the tightly coiled up spring. When the wound up spring gets released to return to its original shape, it turns the wheels of the toy car and makes it run.

P.177-180 Exercises

A. Objective Type Questions

I. Multiple-choice Questions

1. **c.** no displacement takes place.
2. **d.** does not change.
3. **c.** 9 J.
4. **c.** When it is at its natural length.
5. **c.** 40 W

II. Fill in the blanks

1. directly
2. zero
3. Magnitude, direction
4. Pascal
5. 1 unit

III. Assertion–Reasoning Type Questions

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

IV. Very Short Answer Type Questions

1. CGS unit of energy is g cm^2/s^2. The SI unit of energy is joule J = kg m^2/s^2. Hence, the ratio is 10^{-7}.
2. One kilowatt hour is the amount of electrical energy consumed by an electrical appliance of power 1 kilowatt in one hour. One kilowatt is thousand watts and watt is the SI unit of power.
3. Sound energy to electrical energy.
4. No, force applied may not always produce displacement. In such a case, though force is applied, work is not done.
5. Its kinetic energy increases twenty five times.
6. We cannot convert all of the heat energy into mechanical energy. A large percentage of the heat just passes through and comes out of the other side less concentrated and less useful.
7. **a.** When the bob is at the extreme position, it has maximum potential energy.

   b. When the bob is at the centre, it has maximum kinetic energy.
8. Work done on body moving in a circular path is zero. At every point of the circular orbit, centripetal force acts on the moving body at right angle to the direction of the motion of body, i.e. $\theta = 90°$, we know, $W = Fs \cos\theta = Fs \times 0 = 0$.

B. Short Answer Type-I Questions

1. A nail becomes warmer when hammered into a plank because the mechanical energy while hitting with a hammer gets converted into heat energy.
2. Kinetic energy is dependent on mass and velocity. The body of mass $2m$ has higher mass and will have higher velocity as it is dropped from a greater height. Hence, the body of mass $2m$ will have more kinetic energy.
3. Potential energy of stored water in the dam $\rightarrow$ kinetic energy of falling water $\rightarrow$ kinetic energy of blades of turbine $\rightarrow$ electrical energy produced by electric generator.
4. **a.** Potential energy is given by mgh. When height is doubled, the potential energy gets doubled.

   b. When mass is doubled, the potential energy gets doubled.

   c. When the body is taken to moon, the value of g gets reduced hence the potential energy also gets reduced.

C. Short Answer Type-II Questions

1. Kinetic energy = $\frac{1}{2} mv^2$

$$v = \sqrt{\frac{2KE}{m}}$$

   Velocity and mass share an inverse proportionality. Sparrow and a crow having same kinetic energy may differ in their velocities. Since the mass of crow is more than that of sparrow. Its velocity will be lesser than that of sparrow.

2. a. A compressed spring has less potential energy.

b. A stretched spring has higher potential energy.

c. If the body is taken away against the gravitational force, the potential energy increases as the height increases.

3. The potential energy in the head of water is converted into kinetic energy in the turbine which converts the kinetic energy into electrical energy.

Potential Energy of water → Kinetic Energy → Electrical Energy.

D. Long Answer Type Questions

1. Law of conservation of energy states that energy can neither be created nor be destroyed. It can only be converted from one form to another. The total energy before and after the transformation remains the same.

Let *m* be the mass of a body held at position A and at a height *h* above the ground.

At position A

Kinetic energy of the body, KE = 0 (since the body is at rest)

Potential energy of the body, PE = *mgh* (since the body is lifted to a height *h*)

Total mechanical energy at A = KE + PE

= 0 + *mgh* = *mgh*

$E_1 = mgh$

Let the body be allowed to fall freely under gravity. In the free fall, let the body reach the position B with velocity v_1 where AB = *x*

At position B

From the equation of motion

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

$v_1^2 - 0 = 2gx$ (i)

$v_1^2 = 2gx$

Kinetic energy of the body, KE = $\frac{1}{2} mv_1^2$ (ii)

Substituting the value of v_1^2 in equation (ii), we get

$$KE = \frac{1}{2} m(2gx) = mgx$$

Height of the body at B above the ground *CB* = (*h* – *x*)

Therefore, potential energy of the body at B (PE) = *mg* (*h* – *x*)

Total mechanical energy at B (E_2)

= KE + PE

= *mgx* + *mg*(*h* – *x*)

= *mgx* + *mgh* – *mgx*

$E_2 = mgh$

Let the body be allowed to fall freely under gravity, when it strikes the ground at C with a velocity *v*.

At position C

From the equation of motion

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

$v_1^2 - 0 = 2gh$

$v_1^2 = 2gh$ (iii)

Kinetic energy of the body KE = $\frac{1}{2} mv^2$ (iv)

Substituting the value of v^2 in equation (iv), we get

$$KE = \frac{1}{2} m(2gh) = mgh$$

Potential energy of the body at *C* = *mgh*

= *mg* (0) = 0

(since the body is on ground, *h* = 0)

Total mechanical energy E_3 = KE + PE

= *mgh* + 0 = *mgh*

Thus, we find $E_1 = E_2 = E_3 = mgh$

2. Potential Energy At $h_1 = mgh_1$

Therefore the Potential Energy At

$h_1 = m \times 10 \times 10 = 100$ mJ

On striking the ground level, the ball loses 40% of its initial energy:

i.e. 40% × 100 mJ = 40 mJ

The energy left on striking the ground

= 100 mJ – 40 mJ = 60 mJ

So the final energy of the ball, mgh_2 = 60 mJ

i.e $h_2 = \frac{60}{10}$ = 6 m

Hence the ball will bounce back to a height of 6 m.

3. **a.** Displacement = 14.9 – 10 = 4.9 m

Acceleration = *g* = 9.8 m/s²

initial velocity (*u*) = 0 .

Velocity at 10 m height = *v* (suppose)

Time taken to cover the displacement

= *t* (suppose)

using, $S = ut + \frac{1}{2} \times at^2$

we get;

$4.9 = \frac{1}{2} \times 9.8 \times t^2$

= > *t* = 1 second

Then using;

$$v = u + at$$

we get;

$$v = 9.8 \text{ m/s}$$

• For 3 Kg body:

Momentum = mv = 3 × 9.8 = 29.4 Kg m/s²

• For 10 Kg body:

Momentum = 10 × 9.8 = 98 Kg m/s²

b. • For 3 Kg body (PE) :

PE at 10 m height above the ground is given by = 3 × 9.8 × 10 = 294 J

• For 10 Kg body (PE) :

PE at 10 m height above the ground is given by = 10 × 9.8 × 10 =980 J

c. KE of a body is given by:

$$\text{KE} = \frac{1}{2} \times mv^2$$

• For 3Kg body:

$$\text{KE} = \frac{1}{2} \times 3 \times (9.8)^2 = 144.06 \text{ J}$$

• For 10 Kg body :

$$\text{KE} = \frac{1}{2} \times 10 \times (9.8)^2 = 480.2 \text{ J}$$

4. a. KE = 160 J, m = 80 kg

$$\frac{1}{2} \times 80 \times v^2 = 160$$

$$v^2 = \frac{160}{40} = 4$$

$$v = 2 \text{ m/s}$$

b. Net force = 375 N – 25 N = 350 N

c. $F = ma$

$$350 = 80 \times a$$

$$a = \frac{350}{80} = \frac{35}{8} \text{ m/s}^2$$

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

$$4 = 2 \times \frac{35}{8} \times s$$

$$s = \frac{16}{35} \text{ m}$$

e. $W = F \times s$

$$= 350 \times \frac{16}{35} = 160 \text{ J}$$

E. Numerical Problems

1. Force applied = 40 N

Displacement = 10 m

Work done = Force × Displacement

= 40 × 10 = 400 J

2. Force applied = 200 N

Work done = 1000 J

Work done = Force × Displacement

1000 = 200 × Displacement

Displacement = $\frac{1000}{200}$ = 5 m

3. Mass = 1000 kg

Height, h = 20 m

$g = 9.8 \text{ m/s}^2$

Work done in operating the pump

$W = mgh$ = 1000 × 9.8 × 20 = 1,96,000 J

4. Mass = 5 kg

Height = 10 m

$g = 10 \text{ m/s}^2$

Time taken = 10 s

Work done = mgh = 500 J

Power = $\frac{\text{Work done}}{\text{Time taken}}$

Power used by the lady = $\frac{500}{10}$ = 50 W

5. Mass of the boy = 45 kg

Distance = 20 × 0.25 = 5 m

(since there are 20 steps and the height of each step is 25 cm)

$g = 10 \text{ m/s}^2$

Time taken = 20 s

Work done = 45 × 5 × 10 = 2250 J

Power = $\frac{\text{Work done}}{\text{Time taken}} = \frac{2250}{20}$ = 112.5 W

6. Mass of the stone = 3 kg

Height = 100 m

$g = 9.8 \text{ m/s}^2$

Energy released by the stone = Potential energy possessed by it = mgh = 3 × 100 × 9.8 = 2940 J

7. Energy spent = 1000 J

Height = 10 m

$g = 10 \text{ m/s}^2$

Potential energy = mgh = Energy spent

1000 = m × 10 × 10

m = 10 kg

8. Mass of the car = 1500 kg

Initial velocity of the car,

$$u = 36 \text{ km/h} = \frac{36 \times 1000}{60 \times 60} \text{ m/s} = 10 \text{ m/s}$$

Final velocity,

$$v = 72 \text{ km/h} = \frac{72 \times 1000}{60 \times 60} \text{ m/s} = 20 \text{ m/s}$$

We know

$$v^2 - u^2 = 2as$$
$$(20)^2 - (10)^2 = 2as$$
$$300 = 2as$$
$$as = 150$$

Work done = Force × Distance

or $W = F \times s$

$W = m \times a \times s$

Substituting the value of $a \times s$ in the above equation, we get

$$W = 1500 \times 150 = 2{,}25{,}000 \text{ J}$$

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. a. iv. All of these

b. iii. remains constant.

c. iii. half P.E. and half K.E.

d. ii. 6096 kJ

e. iii. 125 m

2. a. iii. A stretched spring

b. ii. 10 m/s

c. iv. initial velocity of the object.

d. i. maximum.

e. ii. 882 W

G. Value-Based Questions (Optional)

1. a. In terms of Physics, Manisha has done no work because there was no displacement. Hence, the work done is zero.

b. We learn that Manisha is a hardworking and intelligent student. She is very helpful as she is helping her friend in discussing the question paper.

2. a. Work is being done by both the teams but Ruby's team applies greater force which causes displacement in the direction of Ruby's team.

b. The values learnt from the game of tug of war are that we should always give our best. We should do everything possible to achieve what we want to.

3. a. The heat energy of the sun heats the air near the surface of the earth. The hot air spreads and becomes lighter. The light, hot air rises up creating a vaccum below. At the same time, cooler air flows in to takes its place. The cooler air flowing from the sides is the wind. This wind possesses kinetic energy and can turn the windmill.

b. The values we learn from Karan are that we should help our friends whenever they are in need. We should share our knowledge with others to help them.

4. a. Two sources of energy derived from the sun's energy are:

- Energy of wind
- Energy of flowing water.

b. We learn that we should be attentive while studying and ask questions from teachers to carry out interactive sessions in class to have better understanding of the subject.

CHAPTER – 6

SOUND

P.187 Check Your Progress 1

A. Multiple-choice Questions

1. **c.** hearing
2. **c.** vibrates
3. **d.** strings
4. **a.** solids
5. **c.** the moon has no material medium

B. Very Short Answer Type Questions

1. Sound is a form of energy which produces a sensation of hearing in our ears. Sources of sound include, guitar, drums, tabla and bells.
2. Sound is produced when a body vibrates.
3. The beads vibrate and a sound is also produced. The vibrating membrane of the drum produces the sound.
4. **a.** String
   b. Membrane
   c. Holes of the pipe
   d. String
   e. Membrane
   f. Membrane
   g. Holes in the pipe
   h. String
5. The substance or matter through which sound is transmitted is called a medium. Medium can be air, solid or liquid.
6. The following conditions are necessary for propagation of sound.
   - a vibrating source for the production of the sound
   - a material medium for the sound to travel through
   - the medium must be continuous and elastic
   - a receiver to receive the sound

C. Short Answer Type-I Questions

1. When a tuning fork is tapped on a rubber stopper and held close to the ear, a sound is heard. This shows that sound is produced by a vibrating body.
2. We cannot hear sound from space because sound needs a medium for propagation and space has no atmosphere. It is vacuum.
3. **a.** Take a metre scale and place it on a table end. Press the metre scale with one hand and flick with other hand. The vibrating metre scale produces sound. If the scale is stopped from vibrating, the sound also stops.
   b. Fix two nails on a wooden board. Tie a rubber band between the two ends of the nail. Stretch the rubber band and then leave it. The rubber band vibrates and sound is produced. If the vibrations of the rubber band stop, there is no sound produced.

D. Short Answer Type-II Questions

1. Differences between sound waves and light waves (Refer to Table 6.2, P-186)
2. Sound can be produced by vibration of a string, blowing air through narrow orifices, beating the membranes of drum and striking the clapper of a bell.
3. Place a wrist watch at one end of the wooden table and stand at the other end of the table. Lying the head on the table enables to hear the tick of the watch. This shows that sound can travel through the wood. It also shows that sound travels better in solids than air because the tick is better heard by lying the head on the table rather than by standing.
4. Take a squeaky toy and put it inside a plastic bag. Seal the bag with the help of a candle or tie the mouth of the bag with a thread. Fill a bucket with water and place the bag in the water. Upon squeezing the toy, a sound will be heard. Placing our ear against the side of the bucket and squeezing the toy makes us hear the sound better. This proves that sound can travel through a solid medium better than in liquid medium.
5. Place the electric bell inside the glass bell jar and connect it to a battery. When the circuit is closed, one can hear the bell ring. The jar contains air and sound travels through this air. Remove the air from the jar using a vacuum pump. As the air is sucked out, the loudness of the sound slowly decreases and finally the sound cannot be heard. This shows that sound needs a medium for propagation.

P.192-193 Check Your Progress 2

A. Multiple-choice Questions

1. **c.** energy
2. **d.** compression
3. **c.** longitudinal
4. **b.** longitudinal wave
5. **a.** longitudinal

B. Very Short Answer Type Questions

1. Wave motion is a vibratory disturbance produced in one part of the medium that travels to another part involving the transfer of energy but not the transfer of any matter with it.
2. **a.** Compression is that part of a longitudinal wave in which the particles of the medium are closer to one another than they normally are. Whereas, rarefaction is that part of a longitudinal wave in which the particles of the medium are farther apart than that in normal position.

   b. In compression there is a momentary decrease in the volume of the medium. Whereas in rarefaction there is a momentary increase in the volume of the medium.

   c. In compression of longitudinal wave the density of particles is high. Whereas in a rarefaction, the density of the particles is less than in the normal.
3. **a.** Based on the requirement for propagation of wave the waves are classified into electromagnetic waves (which do not need a material medium for propagation) and mechanical waves (which need a material medium for propagation).

   b. Based on the direction of periodic changes in the medium, the waves are classified into longitudinal waves and transverse waves.
4. A wave in which the particles of the medium oscillate to and fro in the same direction in which the wave is moving is called a longitudinal wave. For example, sound waves.

C. Short Answer Type-I Questions

1. Characteristics of a wave motion include the following:
   - Wave motion is a periodic disturbance travelling through a medium which is produced by a vibrating body.
   - Wave motion travels at a constant speed in all directions in a medium and transfers energy in the medium.
   - In wave motion, the particles of the medium do not move from one place to another. They only vibrate about their fixed positions passing on energy they possess from particle to particle.
   - During wave motion, the medium does not move as a whole. Only disturbance travels through the medium.
   - Wave motion is possible only in that medium which possesses the properties of elasticity and inertia.
2. Differences between compression and rarefaction:

Parameter	Compression	Rarefaction
Distance between particles	It is that part of a longitudinal wave in which the particles of the medium are closer to one another than in their normal state.	It is that part of a longitudinal wave in which the particles of the medium are farther apart than in their normal state.
Volume of medium	There is a momentary decrease in the volume of the medium.	There is a momentary increase in the volume of the medium.
Density of particles	The density of particles is higher than the normal density.	The density of the particles of the medium if lesser than the normal density.

3. Differences between longitudinal wave and transverse wave:

Parameter	Longitudinal wave	Transverse wave
Vibration of particles	The particles of the medium vibrate to and fro in the same direction in which the wave is moving.	The particles of the medium vibrate up and down perpendicular to the direction in which the wave is moving.
Regions formed	It consists of compressions and rarefactions.	It consists of crests and troughs.
Medium	It can propagate in all types of media.	It can propagate only in solids and surface of liquids.

Pressure and density variation	The pressure and density are maximum at compressions and minimum at rarefactions.	There is no pressure density variation.
Graphical representation	It is represented by density distance graph.	It is represented by displacement distance graph.
Polarisation	It cannot be polarised.	It can be polarised.
Examples	Sound waves, waves formed in a slinky when pulled and pushed.	Ripples produced in water on the surface of a pond, vibrations of strings in musical instruments.

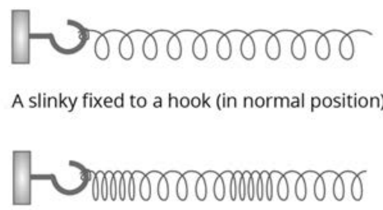
D. Short Answer Type-II Questions

1. When a stone is thrown into the pond, the energy carried by the stone disturbs the water molecules close to it. By gaining energy from the stone, the water molecules near the stone start vibrating up and down. These vibrating water molecules transfer some of the energy to the next set of water molecules which also start vibrating and so on. In this way, a wave is formed.

2. Drop a stone in a pond. It will be observed that circular waves or ripples spreading out in all directions on the surface of water. If a small leaf is placed on the water surface, the leaf will move up and down about its original position but does not move away from or towards the source of disturbance along the waves. This shows that the disturbance moves from one place to another but the water is not carried with it. This proves that waves do not carry matter while travelling.

3. Take a slinky and fix its one end to a hook. This is the normal position of a slinky since all loops are at equal distance. Now, continuously push and pull the free end of the slinky. It will be observed that in the spring, at some places, the turns are closer together than that in the normal position. These regions are called compressions. The number of turns per unit volume are more than that in normal position. In the same spring, at some places, the turns are farther apart than in normal position. These regions are called rarefactions. The number of turns per unit volume are more than that in normal position.

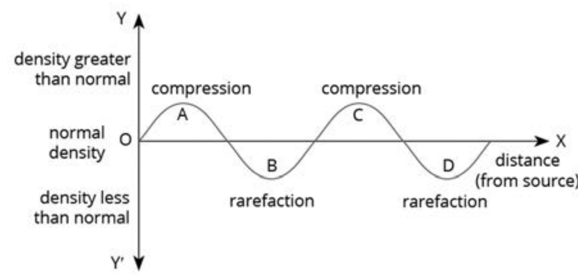
4. A compression is that part of a longitudinal wave in which the particles of the medium are closer to one another than they normally are and there is a momentary decrease in the volume of the medium. A rarefaction is that part of a longitudinal wave in which the particles of the medium are farther apart than that in normal position and there is a momentary increase in the volume of the medium.



A slinky fixed to a hook (in normal position)

Longitudinal waves in a slinky showing compressions and rarefactions

5.



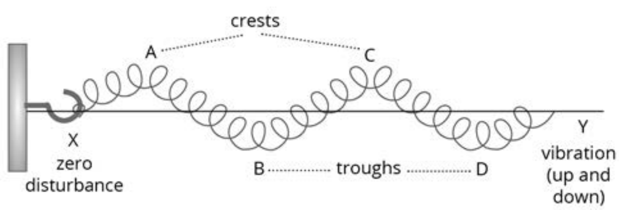
Graphical representation of a longitudinal wave by density–distance graph

6. Take the example of a tuning fork. When the prongs of a tuning fork are not vibrating, the vertical lines representing the air particles or layers are equidistant. When the prongs of the tuning fork are struck against a hard rubber pad, the prongs begin to vibrate. When the prongs move to the right, i.e. towards *n* from the mean position *m*, it compresses the layer of air in contact with it. The volume of these layers at *C* decreases and pressure increases. This pressure difference causes the compressed layer to move forward, without the air layer moving forward. It compresses the next layer and so on. Thus, a wave of compression travels onwards to the right. The disturbance thus passes from one layer to the next, but the layers themselves do not move with the disturbance. When the prongs returns from *n* to the mean position *m*, the compression travels onwards from *C* to C_1. When the prong from the mean position m reaches other extreme position l, the pressure of the air layers adjoining the prong decreases and volume increases. The particles of air which had moved to the right, now, move to the left. While returning, the particles overshoot their mean position due to inertia of motion leading to expansion of air layers near the prong thus, producing rarefaction R, the compression shifts from C_1 to C_2.

When the prong returns from the extreme position l to the mean position m, the rarefaction R shifts to R_1, the compression shifts from C_2 to C_3. Thus, the vibrating tuning fork produces a source of alternating compression and rarefaction in air that travel forward with the speed of waves.

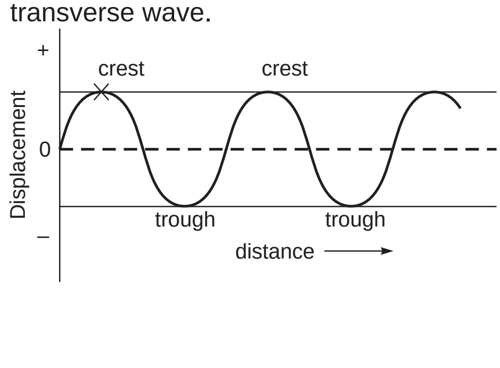
7. Take a slinky and fix its one end to a hook. This is the normal position of a slinky since all the turns are at the same level. When the free end of the slinky is continuously moved up and down rapidly, it will be observed that the portion of slinky which moves up form as an elevation. This region is called a crest. The portion that moves down is called a trough. Crest is the point of maximum positive displacement and trough is the point of maximum negative displacement.

8. Crest is the point of maximum positive displacement and trough is the point of maximum negative displacement of a transverse wave.



Transverse wave in a slinky showing crests and troughs

9. Displacement-distance graph in case of a transverse wave.



P.196-197 Check Your Progress 3

A. Multiple-choice Questions

1. **b.** $\frac{\lambda}{2}$
2. **c.** energy
3. **a.** 0.20 s
4. **b.** wavelength
5. **c.** hertz

B. Very Short Answer Type Questions

1. A wave is produced by a continuous disturbance in a medium.
2. The distance between a compression and an adjacent rarefaction is $\frac{\lambda}{2}$.
3. Wave velocity = Frequency × Wavelength.
4. Points on a wave which are in same state of vibration are said to be in the same phase.
5. It means that the prongs of the tuning fork on hitting a rubber pad would produce 512 vibrations per second.
6. **a.** In a longitudinal wave motion, the distance between tow consecutive rarefactions or between two consecutive compressions is called wavelength.

   b. In a transverse wave motion, the distance between two consecutive crests or between two consecutive troughs is called the wavelength. The SI unit of wavelength is metre.

C. Short Answer Type-I Questions

1. The maximum displacement of the particles of a medium from their mean positions during the propagation of a wave is called the amplitude of the wave. The SI unit of amplitude is metre.
2. It means that the prongs of the tuning fork on hitting a rubber pad would produce 384 vibrations per second.
3. The time required to produce one complete wave is equal to the time period T of the wave. So, if time period is measured in seconds, then

   Number of waves produced in T s = 1

   Number of waves produced in 1 s = $\frac{1}{T}$

   But the number of waves produced in one second is equal to the frequency of the wave, Therefore, $\nu = \frac{1}{T}$.
4. The distance travelled by a wave in one second is called the wave velocity of the wave. Its

SI unit is m/s.

5. Time period T = 0.1 s

Wavelength = 5 cm

We know,

$$v = \frac{1}{T} \times \lambda$$

$$v = \frac{1}{0.1} \times 5 = 50 \text{ cm/s}$$

6. a. Distance travelled by the sound wave = 800 m

Time taken = 2.5 s

Speed of the wave

$$= \frac{\text{Distance travelled by the wave}}{\text{Time taken}}$$

$$= \frac{800}{2.5} = 320 \text{ m/s}$$

b. Frequency, ν = 640 Hz

We know,

Wave velocity v = Frequency (ν) × Wavelength (λ)

$320 = 640 \times \lambda$

$$\lambda = \frac{320}{640} = 0.5 \text{ m}$$

6. The time required to produce one complete wave is called the time period of the wave. The SI unit of time period is second.

7. Wave velocity = 15 m/s

Time period T = 10 s

Therefore frequency, $\nu = \frac{1}{T} = \frac{1}{10}$ Hz

Wave velocity $v = \nu \times \lambda = \frac{1}{T} \times \lambda$

$$15 = \frac{1}{10} \times \lambda$$

$$\lambda = 150 \text{ m}$$

D. Short Answer Type-II Questions

1. Consider a mechanical wave passing through a medium. By definition, the wavelength is the distance travelled by the wave in time T. Therefore, wave velocity

$$v = \frac{\text{Distance travelled by the wave}}{\text{Time taken}}$$

$$v = \frac{\lambda}{T}$$

$$\text{or } v = \frac{1}{T} \times \lambda$$

$$= \nu \times \lambda \left(\text{since } \nu = \frac{1}{T}\right)$$

or Wave velocity = Frequency × Wavelength

2. Wavelength = Distance between the crests

= 100 m

Wave velocity = 25 m/s

Frequency of crest reaching the boat (T) = ?

We know,

Wave velocity $v = \nu \times \lambda$

$$25 = \nu \times 100$$

$$\nu = \frac{25}{100} = \frac{1}{4}$$

So, the crests reach the boat 4 times in one second.

3. Wave velocity = 330 m/s

Frequency (ν) = 550 Hz

We know

Wave velocity $v = (\nu) \times \lambda$

$$330 = 550 \times \lambda$$

$$\lambda = \frac{330}{550} = 0.6 \text{ m}$$

4. a. Distance covered = 8 m

Time taken = 0.05 s

Wave velocity = Distance travelled/Time taken

$$= \frac{8}{0.05} = 160 \text{ m/s}$$

b. Frequency (ν) = 200 Hz

We know,

Wave velocity $v = \nu \times \lambda$

$$160 = 200 \times \lambda$$

$$\lambda = \frac{160}{200} = 0.8 \text{ m}$$

5. Wavelength = 100 m

(since the distance between two crests is the wavelength)

Wave velocity = 20 m/s

$$v = \nu \times \sigma$$

$$20 = \nu \times 100$$

$$\nu = \frac{20}{100} = 0.2 \text{ Hz}$$

6. Wave velocity = 30 cm/s = 0.3 m/s

Frequency (ν) = 20 Hz

Minimum distance between consecutive compressions = wavelength = ?

Wave velocity $v = \nu \times \lambda$

$$0.3 = 20 \times \lambda$$

$$\lambda = \frac{0.3}{20} = 0.015 \text{ m} = 1.5 \text{ cm}$$

7. a. Wavelength = 68 cm = 0.68 m

Distance travelled = 850 m

Time taken = 2.5 s

Wave velocity = Distance travelled/Time taken

$$= \frac{850}{2.5} = 340 \text{ m/s}$$

b. Wave velocity $v = \nu \times \lambda$

$$340 = \nu \times 0.68$$

$$\nu = \frac{340}{0.68} = 500 \text{ Hz}$$

P. 200-201 Check Your Progress 4

A. Multiple-choice Questions

1. **b.** frequency
2. **a.** small amplitude
3. **b.** decibels
4. **a.** tone
5. **b.** waveform

B. Very Short Answer Type Questions

1. A continuous and uniform sound produced by regular and periodic vibrations producing pleasing effect to our ears and mind is called musical sound.
2. **a.** Frequency **b.** Intensity **c.** Waveform
3. **a.** Pitch **b.** Loudness **c.** Quality
4. **a.** Nature of sound produced by an object vibrating with a low frequency is grave or flat.
   b. Pitch of sound produced by an object vibrating with a low frequency is low.
5. **a.** Nature of sound produced by an object vibrating with a high frequency is shrill.
   b. Pitch of sound produced by an object vibrating with a high frequency is high.
6. The thinner strings of a guitar give shriller sounds because thinner strings vibrate with greater frequency than thicker strings.
7. Loudness is a sensation as perceived by the listener. It is a measure of the response of the ear to the wind.
8. Factors affecting loudness of a sound are amplitude of vibration of the source, surface area of the vibrating body, distance from the vibrating body, density of the medium, presence of resonant bodies and motion of the medium.
9. Greater the amplitude of vibration of the source, the greater is the intensity of sound and vice versa.
10. Loudness depends on the distance between the listener and the source. The lesser the distance between the listener and the source, the louder is the sound heard by the listener and vice versa. The loudness of sound varies inversely as the square the distance.
11. The loudness of sound is measured in decibels.
12. Three characteristics of a musical sound are pitch, loudness and quality.

C. Short Answer Type-I Questions

1. The wings of a bee vibrate with a high frequency. That is why the sound produced by the bee is shrill and high pitched.
2. **a.** Wave A will have a higher pitch because it has a shorter wavelength and pitch is inversely proportional to the wavelength.
   b. Wave B will have grave or flat sound because it has longer wavelength and hence will have low pitch as pitch is inversely proportional to the wavelength.
3. **a.** Loudness also will get tripled.
   b. Loudness of sound will also decrease.
   c. Loudness of sound will decrease four times.
   d. Loudness of the sound decreases.
   e. Loudness of sound increases.
4. On striking a drum harder, its skin vibrates with a higher amplitude. Amplitude is directly proportional to loudness.
5. The loudness of a sound is directly proportional to the density of the medium through which it propagates, i.e. the greater the density of the medium, the louder is the sound.
6. The disturbance produced in the environment by undesirable, loud and harsh sound from various sources is called noise pollution. It is caused by fast moving vehicles, running factories, etc.
7. **a.** We can recognise our family members from their voices without seeing them because of a property of musical sound called quality. The voice of each family member has a particular quality.
   b. Two musical notes of the same pitch and same loudness played on a violin and piano are different because they have different waveforms.
8. The voice of children and ladies is shrill as compared to the voice of men. This is because children and ladies have short vocal cords which vibrate with a high frequency to produce a high pitched voice. Whereas men have long vocal cords which vibrate with a low frequency to produce a low pitched voice.

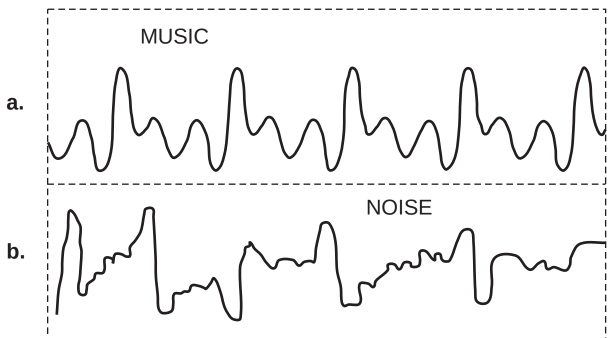
9. Quality is the characteristic of a musical sound that enables us to distinguish between two sounds of the same pitch and loudness produced by two different sources.

D. Short Answer Type-II Questions

1. Differences between musical sound and noise

Parameter	Musical sound	Noise
Effect on ear	It produces pleasing effect to our ears.	It produces unpleasant effect to our ears and mind.
Frequency	The frequency of musical sound is high.	The frequency of noise is low.
Waveform	It produces a regular waveform.	It produces an irregular waveform.

2.



3. Pitch of a sound is influenced by the frequency of vibration or wavelength.

4. When the skin of a tabla is tightened, it vibrates with a higher frequency and hence produces a higher pitch.

5. Loudness of whisper = 20 dB

   Loudness of conversation = 60 dB

   Difference in loudness = 40

   For every 10 decibels that get added, the loudness gets multiplied by 10 or rather, the loudness increases 10 times. Since 40 is 4 times 10 or (4 × 10).

   Loudness of conversation is 10^4 times louder than that of whisper.

6. Loudness of whisper = 20 dB

   The sound of shouting is 10^5 times louder that whisper. Since for every 10 decibels that get added, the loudness gets multiplied by 10 or rather, the loudness increases 10 times, 10^5 times louder must be 5 × 10 decibels = 50 decibels more than loudness of whisper. Hence, the loudness of shouting = 20 + 50 = 70 dB.

7. Noise pollution can lead to the following harmful effects.
   - It may result in the loss of hearing leading to deafness.
   - It increases stress, causes headache and nervous tension resulting in the lack of concentration and the loss of work efficiency.

8. A large drum produces a louder sound than smaller drum because larger drum has a larger surface area and the loudness of sound is directly proportional to the surface area of vibrating body.

9. The loudness of sound is increased due to the presence of other resonant bodies near the source of sound. In a hall, the walls, roof, floor, etc. reflect the sound. Consequently , the loudness is increased. In open air there are no resonant bodies to reflect the sound.

10. Quality of sound depends on waveform, frequency, resonance, etc.

P. 207-208 Check Your Progress 5

A. Multiple-choice Questions

1. **c.** 17.2 m
2. **d.** reverberations
3. **c.** increases
4. **c.** shock waves
5. **c.** microphone

B. Very Short Answer Type Questions

1. A sound board is a concave board that is placed behind the speaker. The speaker is made to stand at the focus of the sound board. The sound board reflects the sound waves of the speaker towards the audience.

2. According to the laws of reflection of sound
   - the angle of incidence is equal to the angle of reflection of sound.
   - the incident sound, the normal and the reflected sound, all lie in the same plane.

3. The speed of sound is defined as the distance which a point on a wave, such as a compression or rarefaction, travels per unit time.

4. Bullet and jet aircraft move with supersonic speed.

5. The bouncing back of sound waves when it strikes a hard surface is called the reflection of sound.

6. Front of high mountain or a valley.

7. The time for which the sensation of sound

persists in our ears after the original sound dies off is called persistence of hearing. It is 0.1 s.

8. When a number of echoes of the original sound are heard, each echo being fainter than the preceding one, such multiple echoes are called reverberations. For example, thunder.

9. A body is said to travel with supersonic speed if its speed is more than that of sound, i.e. 346 m/s.

10. Speed of sound is 346 m/s whereas speed of light is 3×10^8 m/s.

11. We know that

Speed = Distance travelled/Time taken

Speed of sound = 344 m/s (at 22 °C in air)

Time taken = $\frac{1}{10}$ s (persistence of hearing)

Distance travelled = ?

Substituting the values in above formula

$$344 = \frac{\text{Distance travelled}}{\frac{1}{10}}$$

Distance travelled = 34.4 m

Thus, the distance travelled by the sound in going from us to the sound reflecting surface and coming back to us is 34.4 m. So our distance from the sound reflecting source must be half of 34.4 m = 17.2 m.

Hence, the minimum distance from a sound reflecting source to hear an echo is 17.2 m.

12. a. Speed of sound is more in solids than in gas because vibrations occur more efficiently when they are closely packed. In a solid, molecules are closely packed than in gas.

b. If the density of the medium is more, the speed of sound in that medium will be less. Oxygen is 16 times denser than hydrogen. Hence, speed of sound is more in hydrogen than in oxygen.

c. People living near airport have hearing problems because aeroplanes travel at supersonic speed at that. One sonic boom produces sounds of more than 130 decibels which damages the delicate tissues of ear causing hearing problems.

d. Light travels at a speed of 3×10^8 m/s whereas sound travels at a speed of 334 m/s. Since light travels faster than sound, smoke is seen earlier than sound is heard.

13. Megaphone, sound boards and stethoscope.

14. An echo is the repetition of the original sound heard after the sound is reflected from a distance, dense and rigid object.

15. Conditions for formation of echo are

- The minimum distance between the source of sound and the reflector should be at least 17.2 m.
- The size of the reflector must be large.
- The intensity or loudness of the sound should be sufficient for the reflected sound reaching the ear to be audible.

16. a. The speed of sound is more on a summer day because the speed of sound increases with temperature and in the summer, the temperature is high.

b. The supersonic aircraft produces shock waves which carry a large amount of energy which can shatter the glass and windowpanes of houses.

C. Short Answer Type-I Questions

1. A megaphone is horn shaped tube that is used to address a small gathering of people at places like tourist spots, fairs and during demonstrations. It works on the principle of reflection of sound.

2. The following measures are to be taken to reduce reverberations:

- Floors are carpeted.
- The large plane surfaces of the walls and roofs must be covered with sound absorbing materials like compressed fire board, rough plaster, etc.
- Heavy curtains must be kept at the entrance and doors.
- Sound absorbing panels must be kept near the stage.

3. An abrupt change in air pressure that leads to production of sharp and loud sound by shock waves produced by a body travelling with supersonic speed is called sonic boom.

The harmful effects of sonic boom are:

- The supersonic aircraft produces shock waves which carry a large amount of energy which can shatter glass and window panes of the houses and can even damage buildings.
- The supersonic aircraft produced sonic booms that can damage the delicate tissues of the inner ear.

4. Speed of sound (v) = 344 m/s

Time for hearing the echo (t) = 5 s

Distance of reflecting source = ?

We know, $d = \frac{\text{Speed} \times \text{Time}}{2} = \frac{344 \times 5}{2} = 860$ m

$2d = 860 \times 2 = 1720$ m

5. Distance at which the cracker is fired (d) = 102 m

Time taken to hear the echo (t) = 0.6 s

Velocity $v = \frac{2d}{t} = \frac{2 \times 102}{0.6}$ = 340 m/s

D. Short Answer Type-II Questions

1. A megaphone is horn shaped tube used to address small group of people. One end of the megaphone tube is narrow and other end is quite wide. When a person speaks into the narrow end of the megaphone tube, the sound waves produced by his voice are prevented from spreading out by successive reflections from the wider end of the megaphone tube. Due to this, the sound of the voice of the person can be heard over a longer distance.
2. A sound board is a concave board that is placed behind the speaker. The speaker is made to stand at the focus of the concave sound board. The concave surface of the sound board reflects the sound waves of the speaker parallel towards the audience and hence prevents the spreading of sound waves in various directions. Due to this, the sound reaches large distances and even people sitting at the back of the hall can hear the speaker's speech clearly.
3. Factors affecting speed of sound include nature of medium, density, temperature and humidity.

   Effect of nature of medium: The speed of sound in different media is different. This is because the molecules are packed closer in solids and liquids than in air. Since molecules undergo vibrations, they do so more efficiently when they are closer together.

   Effect of density: The speed of sound depends on density of the medium. It has an inverse relationship. If the density of the medium is more, the speed of sound in that medium will be less.

   Effect of temperature: The speed of sound depends on the temperature of the medium. With an increase in temperature, the speed of sound increases.
4. Take two hollow cardboard tubes A and B, each about 1 m length and 5 to 7 cm in diameter. Mount the tubes facing a metal plate and at a distance of about 7–8 cm. Place a watch at the mouth of tube A and try to hear the sound by placing the ear close.

   To tube B, place a screen S made of cardboard to prevent the sound from the watch to reach the ear directly. By moving tube B clockwise or anticlockwise, at some point we can hear the ticking of the watch. This is because the sound waves produced by the watch travel through the first tube A, get reflected by the metal plate, then travel through the second tube A. Upon measuring the angle between tubes and the screen, it will be observed that both tubes make equal angles with the screen. This is because sound follows laws of reflection.

   According to laws of reflection of sound:
   - The angle of incidence is equal to the angle of reflection of sound.
   - The incident sound, the normal and the reflected sound, all lie in the same plane.
5. An echo is the repetition of the original sound heard after the sound is reflected from a distant, dense and rigid object. An echo is heard when the sound waves of original sound gets reflected by hitting against a surface. An echo is heard only if the reflected sound reaches our ears after one tenth of a second.

   Conditions necessary for formation of echoes are:
   - The minimum distance between the source of sound and the reflector should be at least 17.2 m so that the echo is heard distinctly after the original sound is over or dies off.
   - The size of the reflector must be large like mountains, hills, walls, etc. compared to the wavelength of the incident sound for reflection of sound to take place.
   - The intensity or loudness of the sound should be sufficient for the reflected sound reaching the ear to be audible.
6. **a.** Speed of sound is affected by the moving wind because wind drifts the medium along its direction of motion.

   If the wind blows in the same direction in which the sound travels, the velocity of sound increases.

   If the wind blows in the opposite direction in which the sound travels, the velocity of sound decreases.

   b. Sound travels faster on an rainy day than on a dry day because presence of water vapour in air increases the density of air. Since speed of sound is directly related to density, velocity of sound is more in moist air than dry air.

   c. Lightning is seen much earlier than thunder is heard because light travels faster than sound. The speed of light is 3×10^8 m/s whereas that of sound is only 346 m/s.

d. Sound board is placed behind a speaker in an auditorium because the concave surface of the sound board reflects the sound waves of the speaker parallel towards the audience and hence prevents the spreading of sound waves in various directions. Due to this, the sound reaches large distances and even people sitting at the back of the hall can hear the speaker's speech clearly.

7. For the first echo,

Total distance travelled by the sound = $2d_1$

Time (t_1) = 3 s

$v_1 = 340$ m/s

$$v_1 = \frac{2d_1}{t_1}$$

$$340 = \frac{2d_1}{3}$$

$$d_1 = \frac{340 \times 3}{2} = 510 \text{ m}$$

For the second echo,

Total distance travelled by the sound = $2d_2$

Time (t_1) = 4 s

$v_1 = 340$ m/s

$$v_1 = \frac{2d_2}{t_2}$$

$$340 = \frac{2d_2}{4}$$

$$d_2 = \frac{340 \times 4}{2} = 680 \text{ m}$$

Distance between the two cliffs

$= d_1 + d_2 = 510 \text{ m} + 680 \text{ m} = 1190 \text{ m}$

8. Speed of sound (v) = 344 m/s

Time for hearing the echo (t) = 5 s

Distance of reflecting source = ?

We know, $d = \frac{\text{Speed} \times \text{Time}}{2}$

$= \frac{344 \times 5}{2}$

$= 860$ m

9. Speed of sound v = 344 m/s

Time taken to hear the echo t = 4 s

Distance d = ?

We know, $v = \frac{2d}{t}$

$$344 = \frac{2d}{4}$$

$d = 688$ m

10. Distance d = 50 m

Speed of sound v = 320 m/s

Time taken to hear the echo = ?

We know, $v = \frac{2d}{t}$

$$320 = \frac{2 \times 50}{t}$$

$t = 0.3125$ s

11. Speed of sound v = 340 m/s

Time taken to hear the echo t = 2 s

Distance d = ?

We know, $v = \frac{2d}{t}$

$$340 = \frac{2d}{2}$$

$d = 340$ m

12. Speed of sound v = 340 m/s

Time taken to hear the echo t = 5 s

Distance d = ?

We know, $v = \frac{2d}{t}$

$$340 = \frac{2d}{5}$$

$d = 865$ m

13. Distance d = 25 m

Speed of sound v = 330 m/s

Time taken to hear the echo = ?

We know, $v = \frac{2d}{t}$

$$330 = \frac{2 \times 25}{t}$$

$t = 0.15$ s

P.215 Check Your Progress 6

A. Multiple-choice Questions

1. **c.** infrasound
2. **b.** ultrasound
3. **b.** echocardiography
4. **b.** Whale
5. **c.** Pelvic

B. Very Short Answer Type Questions

1. The sound whose frequency lies between 20 Hz and 20000 Hz which we are able to hear is called audible sound.

2. The audible range of human ear is 20 Hz to 20000 Hz.
3. Sounds having frequency less than 20 Hz and more than 20,000 Hz are not audible to humans and are called inaudible sounds.
4. Inaudible sounds having frequency less than 20 Hz are called infrasonic sound.
5. Oscillating pendulum produces infrasonic sound.
6. Inaudible sounds having frequency more than 20,000 Hz are called ultrasonic sounds. Ultrasonic waves are high frequency waves that penetrate deep inside.
7. The technique of obtaining images of the internal organs of the body organs by using ultrasonic waves is called ultrasonography.
8. The technique of obtaining images of the heart of the body using ultrasonic waves is called echocardiography.
9. The three bones of middle ear are hammer, anvil and stirrup.
10. The three bones in the middle ear namely hammer, anvil and stirrup increase the strength of vibrations coming from the eardrum before passing them to the inner ear. So their function is to amplify the vibrations several times in the middle ear.
11. Ultrasound can be used to clean machine and engines and to detect cracks in metal blocks.
12. Bat uses the techniques of echolocation to locate its prey. It emits a series of high frequency ultrasonic waves. If any prey is flying in its path, these high pitched ultrasonic waves strike the prey and get reflected. The reflected ultrasonic waves are received as echoes by the bats ear. The nature of reflections gives the bat an indication of the distance of the prey from it, size of the prey and direction of movement of the prey.

C. Short Answer Type-I Questions

1. Inaudible sounds having frequency less than 20 Hz are called infrasonic sound. Rhinoceros, whales and elephants communicate through infra sounds.
2. Children under age five can hear sound up to 25 kHz but adults can't because as people grow older, their ears become less sensitive to higher frequency.
3. Ultrasound can be used as an effective cleaning agent. Objects to be cleaned are placed in a cleaning solution and ultrasonic waves are passed into the solution. Due to their high frequency, the ultrasound waves stir up the cleaning solution. Due to stirring, the particles of dust, grease and dirt sticking to the dirty object vibrate at a very high speed. Very fast vibrations make the particles of dust and grease loose. As a result, these particles get detached from the dirty object and fall into the solution. Then, these particles are removed and object gets cleaned thoroughly.
4. An ultrasound scanner is a medical instrument which is used by doctors to detect abnormalities such as stones in the gall bladder and kidney or tumours in different organs.
5. Kidney stone are hard deposits which can grow inside a person's kidneys. They can be painful and dangerous to life. Ultrasonic waves are directed towards kidneys. These waves break the stones into tiny pieces so that they pass out of the kidney along with urine.
6. **a.** We cannot hear any sound on vibrating our hands forwards and backwards because the frequency of that sound is less than 20 Hz.
   b. Owners of dogs use Galeton whistle because it produces the sounds of frequency more than 20,000 Hz and the owners of dogs can use them without the knowledge of any person located nearby.

D. Short Answer Type-II Questions

1. Images of heart can be obtained by echocardiography. In this technique, ultrasonic waves are sent to the various parts of the heart. The ultrasonic waves travel through the tissues of the heart and get reflected. The reflected ultrasonic waves when fed in the computer et converted into electrical signals which form the image of the heart.
2. Ultrasonography is used for examination of foetus during pregnancy. It is used to monitor growth, development and well being of the foetus. It is also used to detect foetal abnormalities. This diagnosis allows appropriate treatment to be given during pregnancy and childbirth.
3. Sound travels in air as longitudinal waves. When a compression of the medium reaches the eardrum, the pressure on the outside of the membrane increases and forces the eardrum inwards. Similarly when a rarefaction of the medium reaches the eardrum, the pressure on the outside of the membrane decreases and forces the eardrum to relax outwards. This continuous inward and outward movement of the eardrum sets itself into vibrations.

4. Cochlea is filled with a fluid and has many hair cells inside it. The vibrating eardrum causes the three bones in the middle ear to vibrate. The vibrating bones pass their vibrations to the cochlea. The sensitive hair cells present in the cochlea respond to the sound vibrations received and change them into nerve impulses. These impulses are then carried by the auditory nerves to the brain. The brain on receiving the nerve impulses decodes them into specific sounds.
5. To detect cracks in metal blocks from one end, ultrasonic waves are allowed to pass through the metal block and detectors are placed on the other end which detects the transmitted waves. On passing the ultrasound through the metal block, if it passes unreflected as per the report of the ultrasound detectors, then the metal block does not have any internal cracks or holes. If there is a small crack or a hole, the ultrasound gets reflected back from that defect.
6. Ultrasonography is the technique of obtaining images of the internal organs of the body by using ultrasonic waves. An ultrasound scanner is a medical instrument which is used by doctors to detect abnormalities such as stones in the gall bladder and kidney or tumours in different organs. In this technique, the ultrasound scanner produces ultrasound which travels through the tissues of the body, and if there are stones in the gall bladder or kidney or there is a tumour in any internal organ, then ultrasound gets reflected from these organs. These reflected ultrasonic waves are fed into the computer. The reflected ultrasound waves are converted into electrical signals, generating a three-dimensional image of the organ on the monitor of the computer or can be printed on a film.
7. Velocity of sound in water = (v) = 1500 m/s

   Time taken by the pulse to travel (t) = 2 s

   Distance (d) travelled by sonar = ?

   We know $v = \frac{2d}{t}$

   $1500 = \frac{2d}{2}$

   $d = 1500$ m
8. Let the length of the iron pipe be n m

   Speed of sound in air = 344 m/s

   We know,

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

   or $\text{Speed} = \frac{\text{Length}}{\text{Time}}$

   $\text{Time} = \frac{\text{Length}}{\text{Speed}}$

   So, time taken by sound waves in air = $\frac{n}{344}$ (i)

   Speed of sound in iron = 1530 m/s

   So, time taken by sound waves in iron = $\frac{n}{1530}$ (ii)

   Dividing equation (i) by equation (ii), we get

   $$\frac{\text{Time taken by sound wave to travel in air}}{\text{Time taken by sound wave to travel in iron}}$$

   $$= \frac{\frac{n}{344}}{\frac{n}{1530}}$$

   $$= \frac{1530}{344} = \frac{4.45}{1}$$

   Therefore, the ratio of times taken by the sound waves to travel in air and in iron to reach the second child = 4.45 : 1.
9. Velocity of radiowaves (v) = 3×10^8 m/s

   Time taken by the signal to reach earth (t) = 2.5 s

   Distance (d) of moon from earth = ?

   We know $\sigma = \frac{2d}{t}$

   $3 \times 10^8 = \frac{2d}{2.5}$

   $d = 3.75 \times 10^8$ m

P. 217 Higher Order Thinking Skills (HOTS) Questions

A. Multiple-choice Questions

1. **a.** of mixture of several frequencies.
2. **a.** sound will be louder but pitch will not be different
3. **b.** amplitude
4. **b.** infrasound
5. **c.** frequency of the sitar string with the frequency of other musical instruments

B. Very Short Answer Type Questions

1. No. We cannot hear the sound produced by a bell on the moon because on the moon there is no atmosphere. It is vacuum on the surface of moon and sound needs a material medium to travel.
2. SONAR (Sound Navigation and Ranging).
3. Sound produced by a vibrating pendulum is of a frequency less than 20 Hz, i.e. it is infrasonic. Hence, it is not in the audible range of human ear.

C. Short Answer Type-I Questions

1. Though pendulum cannot be used in space, they can see a watch as electromagnetic waves do not need a material medium for propagation.

2. The voice of women is of higher pitch as compared to the voice of men. This is because women have short vocal cords which vibrate with a high frequency to produce a high pitched voice. Whereas men have long vocal cords which vibrate with a low frequency to produce a low pitched voice.

3. The higher the frequency, higher is the pitch of the musical sound. Higher the amplitude, louder is the musical sound.

D. Short Answer Type-II Questions

1. Two musical notes of the same pitch and loudness produced by two different sources have different waveforms because of different quality of musical note.

2. Frequency = 120 kHz = 1.2×10^5 Hz

   Velocity of sound = 344 m/s

   We know wave velocity

   (v) = Frequency (ν) × Wavelength (λ)

   $344 = 1.2 \times 10^5 \times \lambda$

   $$\lambda = \frac{344}{1.2 \times 10^5} = 0.0028667 \text{ m}$$

3. Velocity of ultrasound (v) = 1600 m/s

   Time taken for signal detection (t) = 4 s

   Distance (d) of the seabed from ship = ?

   We know $v = \frac{2d}{t}$

   $1600 = \frac{2d}{4}$

   $d = 3200$ m

P. 217–220 Exercises

A. Objective Type Questions

I. Multiple-choice Questions

1. **c.** Microphone.
2. **b.** 340 m/s
3. **d.** musical notes of an orchestra.
4. **b.** 1.5 cm
5. **b.** A pulse is a sudden disturbance of short duration.

II. Fill in the blanks

1. medium
2. Radio waves and X-rays
3. temperature
4. Echocardiography
5. ultrasonic

III. Assertion–Reasoning Type Questions

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

A. Very Short Answer Type Questions

1. **a.** Amplitude
   b. Frequency
2. Wave velocity (v) = Frequency (ν) × Wavelength (λ)
3. Ultrasound scanner.
4. Two factors affecting speed of sound are nature of medium and temperature.
5. Dogs and dolphins.
6. SI units for frequency is hertz and that for wavelength is metre.
7. Iron, because sound travels fastest in solids.
8. We prefer ultrasonic frequencies for real life applications because these do not fall in human audible range, hence do not cause any disturbance.
9. 0.1 s
10. No, sound needs a material medium for propagation.

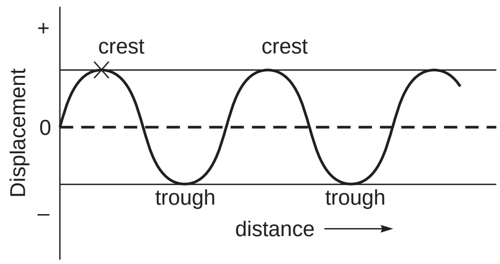
B. Short Answer Type-I Questions

1. Velocity of sound is more in steel because steel is a solid and molecules in solid vibrate more efficiently as they are tightly packed than in air or water.
2. A car travels slower than the speed of sound, and so the sound of the engine and the wheels against the surface travels faster then the car itself, hence, we can hear it as the car approaches us.
3. Explosion in stellar space is not heard on earth because sound needs a material medium for propagation. There is no material medium in space. There is only vacuum.
4. Ultrasound is better than *X*-rays at distinguishing subtle variations between soft, fluid-filled tissues. Unlike *X*-rays, it does not damage tissues with ionising radiation.
5. Echo cannot be heard everywhere because there are certain conditions needed for formation of echo.
   The minimum distance between the source and the reflector must be at least 17.2 m.
   The size of the reflector must be large. The intensity or loudness of the sound must be sufficient for the reflected sound reaching the ear to be audible.

6. As the bottle fills up, the air column or amount of air inside the bottle decreases. So as a result, the pitch or shrillness of the sound will increase, as frequency or pitch of sound is inversely proportional to the length of vibrating air column. Also the amplitude or the loudness of the sound will decrease, as the amount of the air column vibrating decreases as the bottle fills up. So, with the increase in shrillness of the sound, we can detect the filling up of the bottle. So the more the shrillness, the more the bottle has been filled.

C. Short Answer Type-II Questions

1.



Consider a mechanical wave passing through a medium. By definition, the wavelength is the distance travelled by the wave in time *T*, therefore,

$$\text{Wave velocity } (v) = \frac{\text{Distance travelled by the wave}}{\text{Time taken}}$$

$$v = \frac{\lambda}{T}$$

or $$v = \frac{1}{T} \times \lambda$$

$$= \nu \times \lambda \left(\text{since } \nu = \frac{1}{T}\right)$$

or Wave velocity = Frequency × Wavelength

2. Sound travels in air as longitudinal waves. When a compression of the medium reaches the eardrum, the pressure on the outside of the membrane increases and forces the eardrum inwards. Similarly, when a rarefaction of the medium reaches the eardrum, the pressure on the outside of the membrane decreases and forces the eardrum to relax outwards. This continuous inward and outward movement of the eardrum sets itself into vibrations.

Middle ear: The middle ear begins with the inner side of the eardrum. The eardrum is attached to three bones – the hammer, the anvil and the stirrup. These three bones in the middle ear increase the strength of vibrations coming from the eardrum before passing them to the inner ear. The middle ear transmits the amplified sound waves into the inner ear.

3. The large plane surfaces of the walls and roofs of the stage of auditoriums are covered with sound absorbing materials like compressed fire board, rough plaster, etc.

Floors are carpeted and, heavy curtains are kept at the entrance and doors, sound absorbing panels are kept near the stage to reduce reverberations.

D. Long Answer Type Questions

1.

Parameter	Longitudinal wave	Transverse wave
Vibration of particles	The particles of the medium vibrate to and fro in the same direction in which the wave is moving.	The particles of the medium vibrate up and down perpendicular to the direction in which the wave is moving.
Regions formed	It consists of compressions and rarefactions.	It consists of crests and troughs.
Medium	It can propagate in all types of media.	It can propagate only in solids and surface of liquids.
Pressure and density variation	The pressure and density are maximum at compressions and minimum at rarefactions.	There is no pressure density variation.
Graphical representation	It is represented by density–distance graph.	It is represented by displacement–distance graph.
Polarisation	It cannot be polarised.	It can be polarised.
Examples	Sound waves, waves formed in a slinky when pulled and pushed.	Ripples produced in water on the surface of a pond, vibrations of strings in musical instruments.

2. An echo is the repetition of the original sound heard after the sound is reflected from a distance, dense and rigid object.

a. Bat uses the techniques of echolocation to locate its prey. It emits a series of high frequency ultrasonic waves. If any prey is flying in its path, these high pitched ultrasonic waves strike the prey and get reflected. The reflected ultrasonic waves are received as echoes by the bats ear. The nature of reflections gives the bat an indication of the distance of the prey from it, size of the prey and direction of movement of the prey.

b. Dolphins use echolocation to locate food. They send out pulsed sounds of high intensity and frequency that are reflected back when they strike a target. This echo helps the dolphin or whale identify the size and shape of an object, the direction in which the object is moving and enables them to estimate how far away the object is.

E. Numerical Problems

1. Number of beats per minute = 75,

i.e. number of beats in 60 s = 75

Frequency is number of beats per second = 75/60 = 1.25 Hz

2. Frequency = 660 Hz

Velocity of sound = 330 m/s

We know wave velocity (v) = Frequency (ν) × Wavelength (λ)

$$330 = 660 \times \lambda$$

$$\lambda = \frac{330}{660} = 0.5 \text{ m}$$

3. Time period of the pendulum clock $T = 0.2$ s

We know, frequency (ν) = $\frac{1}{T}$

$$\nu = \frac{1}{0.2} = 5 \text{ Hz}$$

4. Velocity of sound = 330 m/s

Wavelength (λ) = 3 m

Frequency = ?

We know wave velocity (v) = Frequency (ν) × Wavelength (λ)

$$330 = \nu \times 3$$

$$\nu = \frac{330}{3} = 110 \text{ Hz}$$

5. a. Number of waves passing through a point in 0.1 s = 50

Therefore, number of waves passing through the point in 1 s, or frequency (ν) = 500 Hz

b. Distance between a crest and adjacent trough = 0.34 m

We know distance between a crest and adjacent trough = $\frac{1}{2}\lambda$

Therefore, $\lambda = 2 \times 0.34 = 0.68$ m

Wave velocity (v) = Frequency (ν) × Wavelength (λ)

$$= 500 \times 0.68 = 340 \text{ m/s}$$

6. Velocity of sound in air (v) = 330 m/s

Time taken to hear the echo (t) = 4 s

Distance (d) of the cliff from child = ?

We know, $v = \frac{2d}{t}$

$$330 = \frac{2d}{4}$$

$$d = 660 \text{ m}$$

7. Distance between a crest and a trough D = 20 cm

Therefore, distance between two crests, i.e. wavelength (λ) = 40 cm

Number of ripples produced per second, i.e. frequency (ν) = 20

We know frequency $\nu = \frac{1}{T}$

$$20 = \frac{1}{T}$$

Therefore, $T = 0.05$ s

Wave velocity (v) = $\nu \times \lambda$

$$= 20 \times 0.4$$

$$= 8 \text{ m/s}$$

8. Velocity of sound (v) = 330 m/s

Time taken for hearing (t) = 2 s

Distance (d) of the person from the cliff = ?

We know $v = \frac{2d}{t}$

$$330 = \frac{2d}{2}$$

$$d = 330 \text{ m}$$

F. Source-based/Case-based/Passage-based/ Integrated Assessment Questions

1. a. i. ultrasonic waves.

b. iii. sound waves

c. iii. rhinoceros

d. ii. echolocation

e. iii. 300 m

2. a. i. Guitar

b. iii. Drum

c. i. Metal plates

d. ii. amplitude.

e. ii. pitch

F. Value-Based Questions (Optional)

1. a. On flicking the scale, it starts vibrating. Vibration is the to and fro motion of an object. Sound is produced when a body vibrates.

   b. The values learnt from Khushi are togetherness, friendship and activeness.

2. a. No, Divisha will not be able to hear any sound produced by Smita because sound requires a material medium to travel. There is vacuum on the surface of the moon, hence, no medium for sound to propagate.

   b. We learn that Divisha and Smita are intelligent, smart and active.

3. a. We should not clean the middle ear with a matchstick or any other pointed object as this can damage the eardrum and can make a person deaf.

   b. The values we learn from Suparna are alertness, caring and smartness.

4. a. If we strike a drum softly, its skin vibrates with a smaller amplitude and a soft sound is produced because loudness is directly proportional to amplitude.

   b. Caring others, helping others, etc.