Motion (English Medium)

Exercise 14:

Solution 1.1:

- Displacement
  Displacement is a vector quantity. Hence, it needs both magnitude and direction to be completely defined.

Solution 1.2:

- zero
  As the initial and final points are same, the displacement is zero.

Solution 1.3:

A. 15

$$54\ \text{km/h} = \frac{54 \times 1000}{1 \times 3600}\ \text{m/s} = 15\ \text{m/s}$$

Solution 1.4:

C. 10 km

$$\text{Distance} = \text{speed} \times \text{time}$$

$$\Rightarrow D = 30\ \text{km/h} \times \left(\frac{20}{60}\right)h$$

$$\Rightarrow D = 10\ \text{km}$$

Solution 1.5:

- 13 km
  Here, the displacement will be given by joining the initial and starting points, i.e. by the hypotenuse of the right angled triangle formed.

$$\text{Displacement} = \sqrt{(5)^2 + (12)^2}$$

$$\text{Displacement} = \sqrt{25 + 144} = 13\ \text{km}$$

Solution 1.6:

- non-uniform motion
  If the velocity-time graph for a body in motion is a straight line parallel to the time axis, then the body is in uniform motion.

Solution 1.7:

- uniformly accelerated motion
  The graph represents uniformly accelerated motion, where the velocity of the body increases with time.

Solution 1.8:

D. 2 m/s^2

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

$$\Rightarrow a = \frac{15 - 5}{5} = 2\ m/s^2$$

Solution 1.9:

- Vehicle A – acceleration, Vehicle B – retardation
  The slope of vehicle A is increasing and the slope of vehicle B is decreasing.

Solution 1.10:

A. 6 m/s

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

$$\Rightarrow 1.5 = \frac{\Delta v}{4}$$

$$\Rightarrow \Delta v = 6\ m/s$$

Thus, the increase in velocity is 6 m/s.

Exercise 15:

Solution 2.1:

Displacement of an object in unit time is called the velocity of the object.

Solution 2.2:

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

Solution 2.3:

Change in velocity of an object in motion, in unit time is called acceleration.

Solution 2.4:

The motion is said to be non-uniform.

Solution 2.5:

For a body having uniform motion, the distance-time graph is a straight line parallel to x-axis (time axis).

Solution 2.6:

A body performing uniform circular motion is said to be in accelerated motion.

Solution 2.7:

Average speed of a body in motion cannot be zero.
Average velocity of a body in motion can be zero.
Example: If a body starts its motion from a point and comes back to the same point after a certain time, the displacement is zero, the average velocity is also zero, but the total distance travelled is not zero and therefore, the average speed in not zero.

Solution 2.8:

Example: A car initially moving with a velocity, say 20 m/s comes to rest in 5 s on applying brakes, then the change in velocity is 0 – 20 = -20 m/s. Therefore, the acceleration is negative and the motion of the car is said to be retarded.

Solution 3.1:

If an object travels an equal distance in the same intervals of time, the object is said to be moving with a uniform motion.
If an object in motion does not travel an equal distance in the same intervals of time, it is said to be in non-uniform motion.

Solution 3.2:

Distance travelled by a body gives the total length of the path of motion whereas displacement shows the final effect of the motion.
Distance is always positive but displacement can be positive, negative or zero. Magnitude of displacement can be less than or equal to the magnitude of distance, but can never be greater than the distance.
Distance is a scalar quantity while displacement is a vector quantity.

Solution 3.3:

The ratio of the total distance travelled by the body to the total time of journey is called its average speed.

$$\therefore \text{Av. speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

It is also the average of values of speeds evaluated over equal intervals of time.
Its S.I. unit is m/s.

Solution 3.4:

Speed	Velocity
1. The distance travelled per second by a moving object is called its speed.	1. The distance travelled per second by a moving object in a particular direction is called its velocity.

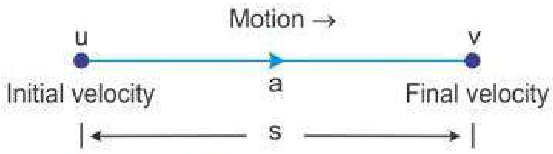
2. It is a scalar quantity.	2. It is a vector quantity.
3. The speed is always positive as direction is not taken into consideration.	3. The velocity can be positive or negative depending upon the direction of motion.

Solution 3.5:

Acceleration	**Retardation**
1. If the velocity of a body increases with time, the body undergoes acceleration.	1. If the velocity of a body decreases with time, the body undergoes retardation.
2. Acceleration is always positive.	2. Retardation is always negative.
3. Mathematically, it is the increase in velocity per second.	3. Mathematically, it is the decrease in velocity per second.

Solution 3.6:

Suppose a body is travelling with uniform acceleration along a straight path. Its initial velocity at time t = 0 is u, its final velocity at t = t is v.



As per the definition of acceleration,

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

$\therefore$ at = v - u

So, v = u + at ....(i)

Now, distance travelled by the object = Av velocity x time

$\Rightarrow S = \frac{u + v}{2} \times t$

Substituting value of v from equation (i),

$S = \frac{1}{2}(u + u + at) \times t$

$S = \frac{1}{2}(2u + at) \times t$

$S = ut + \frac{1}{2}at^2$......................(ii)

Squaring both sides of equation (i),

$v^2 = (u + at)^2$

$v^2 = u^2 + 2\,uat + a^2t^2$

$v^2 = u^2 + 2a\left(ut + \frac{1}{2}at^2\right)$

From (ii),

$v^2 = u^2 + 2aS$

$\Rightarrow v^2 - u^2 = 2aS$ ....(iii)

Equations (i), (ii) and (iii) are the equations of motion.

Solution 3.7:

The motion of a body with constant speed along a circular path is called uniform circular motion.

Though the speed remains constant, the velocity changes at every point of the uniform circular motion due to the change in direction. Tangent drawn at any point on the circular path gives the direction of velocity at that point.

Uniform circular motion is accelerated motion.

Solution 3.8:

The uses of the velocity-time graph are:

1. It enables us to know whether the motion is uniform or non-uniform. Graph for uniform motion is parallel to the time axis. Graph of any other shape depicts non-uniform motion.
2. The slope of velocity-time graph gives the value of acceleration.
   The area enclosed by the velocity-time graph gives the value of distance travelled by the body in that time interval.

Solution 4.1:

$$\text{Distance travelled}(S) = \frac{1}{2} \times \text{Circumference}$$

$$S = \frac{1}{2} \times (2\pi r)$$

Here, r = radius of the circle = 100 m

$$\Rightarrow S = \frac{22}{7} \times 100 = 314.3 \text{ m}$$

Displacement = Diameter of the circle = 2 r

$\therefore$ Displacement = 2 × 100 = 200 m

Solution 4.2:

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

$$\Rightarrow \text{Av. speed} = \frac{100}{10} = 10 \text{ m/s}$$

$$\text{or, Av. speed} = 10 \times \frac{3600}{1000} \text{ km/h} = 36 \text{ km/h}$$

Solution 4.3:

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

$$\Rightarrow \text{Av. speed} = \frac{S + S}{\left(\frac{S}{v_1}\right) + \left(\frac{S}{v_2}\right)}$$

$$\Rightarrow \text{Av. speed} = \frac{2S}{S\left(\frac{v_1 + v_2}{v_1 v_2}\right)}$$

$$\Rightarrow \text{Av. speed} = \frac{2v_1 v_2}{v_1 + v_2}$$

Exercise 16:

Solution 4.4:

Average speed is the average of values of speeds evaluated over equal intervals of time.

Here, the speeds in equal interval of time (at 15 min. intervals) are given.

$\therefore$ Average speed $= \frac{48 + 56}{2} = 52$ km/h

Solution 4.5:

Given, speed = 60 km/h
Time = 30 min = 0.5 h
Distance covered = speed x time
$\therefore$ S = 60 x 0.5 = 30 km
Final odometer reading = Initial reading + Distance covered
$\therefore$ Final odometer reading = 8245 + 30 = 8275 km

Solution 4.6:

$$\text{Retardation} = \frac{\text{Initial velocity - final velocity}}{\text{Time taken}}$$

$$\Rightarrow \text{Retardation} = \frac{(72 - 18) \times \frac{5}{18}}{10} \text{m/s}^2$$

$$\Rightarrow \text{Retardation} = \frac{270}{180} = 1.5 \text{ m/s}^2$$

Solution 4.7:

$$\text{Retardation} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

$$\Rightarrow 0.5 = \frac{\text{Change in velocity}}{40}$$

$\Rightarrow$ Change in velocity = 20 m/s
Since the train stops, final velocity (v) = 0
Let 'u' be the initial velocity.
Then, 20 = u - v
$\Rightarrow$ u = 20 m/s
Let the desired distance be S.

Then, $S = ut + \frac{1}{2}at^2$

$$\Rightarrow S = (20)(40) + \frac{1}{2}(-0.5)(40)^2$$

$\Rightarrow$ S = 800 - 400 = 400 m

Solution 4.8:

Here, radius (r) = 66 m
Time taken to complete one round (t) = 132 s

$$\therefore \text{Av. speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$\text{or, Av. speed} = \frac{2\pi r}{132} \text{ m/s}$$

$$\text{or, Av. speed} = \frac{2\pi \times 66}{132} = 3.14 \text{ m/s}$$

Solution 4.9:

1. The particle is stationary in the time interval of 10 s to 20 s as the displacement-time graph is a straight line parallel to the time axis during this time interval.
2. Velocity in OA part = Slope of line OA = 30/10 = 3 m/s
   Velocity in AB part = 0 m/s, as the particle is stationary.
   Velocity in BC part = Slope of line BC

$$= \frac{(50 - 30)}{(30 - 20)} = 2 \text{ m/s}$$

Solution 4.10:

i. Maximum speed = 10 m/s.

It is maintained from t = 40 s to t = 420 s i.e. for 380 s.

ii. Acceleration in OA part = Slope of line OA= $\frac{10}{40} = 0.25\ m/s^2$

Acceleration in AB part = 0 m/s^2, as the v-t graph is a straight line parallel to the time axis in this part.

Acceleration in BC part = Slope of line BC, which is negative.

Hence, retardation in BC part = $\frac{10-0}{500-420} = 0.125\ m/s$

iii. Total distance travelled (S) = Area under v-t graph

$$\therefore\ S = \left(\frac{1}{2} \times 10 \times 40\right) + (10 \times 380) + \left(\frac{1}{2} \times 10 \times 80\right)$$

$$\Rightarrow\ S = 200 + 3800 + 400 = 4400\ m\ \text{or}\ 4.4\ km$$