Problems Based on Speed and Velocity

VERY SHORT ANSWER TYPE QUESTIONS :

Q.1 Define speed. Write it S.I. unit.

Sol. The distance covered by a body per unit time is called speed. The S.I. unit of speed is ms^{-1}

Q.2 Is velocity a vector physical quantity or a scalar physical quantity?

Sol. Velocity is a vector quantity as it is defined 'displacement of body per unit time'.

Q.3 Write dimensions of speed and velocity.

Sol. Speed and velocity both have same dissensions $[M^0LT^{-1}]$.

Q.4 Are the magnitudes of average speed and velocity are equal.

Sol. No, if the body is not moving in a straight line then the magnitudes of average speed and velocity are unequal.

Q.5 Can a particle have varying speed but constant velocity?

Sol. No, it is not possible. In constant velocity both speed and direction remains constant.

Q.6 Can the speed and velocity of a body be negative?

Sol. The speed of a body cannot be negative, but the velocity can be negative.

Q.7 The displacement of a body is zero. Which of the following physical quantity is strictly zero.
(i) speed (ii) velocity

Sol. Velocity (average)

Q.8 When velocity is constant, does the average velocity over any interval of time differ from the instantaneous velocity ?

Sol. Since velocity is constant therefore average velocity over any interval of time is equal to the instantaneous velocity.

SHORT ANSWER TYPE - I QUESTIONS :

Q.9 Define uniform and variable velocities.

Sol. A body is said to poses uniform velocity if it covers equal displacement in equal time intervals. The velocity is said to be variable velocity if the magnitude of displacement are different in equal intervals of time or the direction of motion is changing .

Q.10 Define average speed.

Sol. The average speed over any interval of time is defined as the ratio of the distance travelled during that interval divided by the interval.

Q.11 Position time graph of the objects A and B is given below. Which object has more velocity?

Sol. Object-B as the slope of the displacement time graph in second case is more than in first.

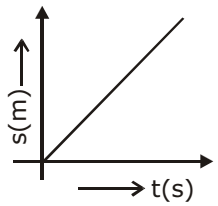

fig (a)

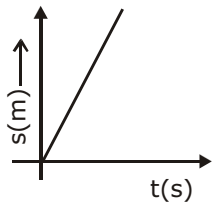

fig (b)

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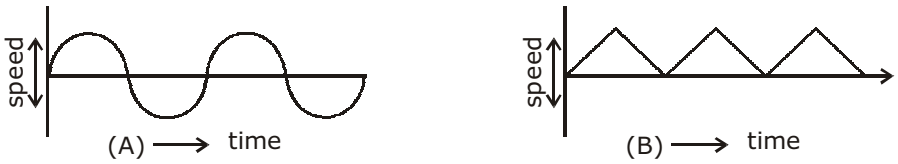
Q.12 The average velocity of a particle is equal to its instantaneous velocity. What is the shape of the displacement-time graph?

Sol. When the average velocity is equal to the instances velocity, the velocity is uniform, so the displacement time graph is a straight line.

Q.13 Which one of the following graphs is not possible.

Sol. Graph (A) is not possible as the speed of an object can not be negative.

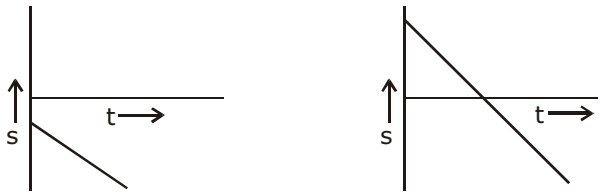


Q.14 What does speedometer measures, the average speed or the instantaneous speed.

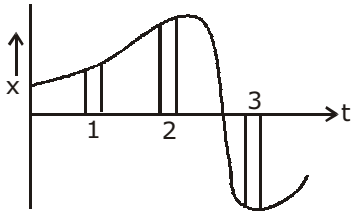
Sol. The speedometer of an automobile measures the instantaneous speed.

Q.15 What is common between the two graphs shown below

Sol. Both the graphs represent negative velocity.



Q.16 Figure below gives the x-t graph of a particle in one dimensional motion. Three different equal intervals are shown. In which interval is the average speed greatest and in which it is the least? Give the sign of average velocity for each interval.



Sol. Greatest in interval 3, least in interval 2.

$v > 0$ in interval 1 and interval 2.

$v < 0$ in interval 3.

Problems Based on Speed and Velocity

Q.17 What conclusion can you draw if the average velocity is equal to instantaneous velocity?

Sol. The particle is moving with constant velocity.

Q.18 Under what condition the magnitude of average velocity is equal to average speed?

Sol. When a particle is moving with constant velocity, the magnitude of it's average velocity is equal to average speed.

Q.19 Why the speed of the object can never be negative?

Sol. Speed is distance covered per unit time. Since distance cannot be negative therefore speed cannot be negative.

Q.20 Under what circumstances, does the relationship $\Delta x = V.\ \Delta t$ hold exactly?

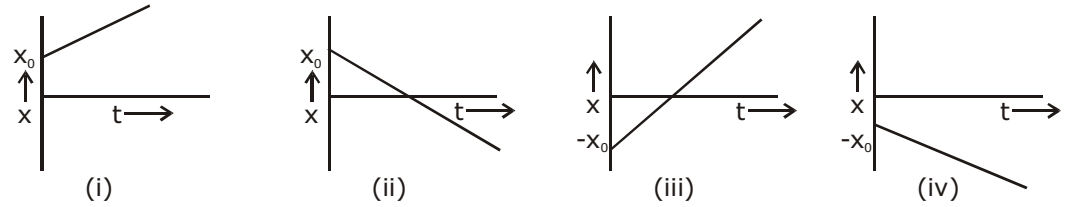
Sol. The given relationship holds good only if the body is moving with uniform velocity.

Q.21 A particle is moving with uniform velocity v along a straight line. What will be the position time graph of the motion of the particle in the following cases?

(i) +ve x_0, +ve v (ii) +ve x_0, –ve v (iii) –ve x_0 , +ve v (iv) –ve x_0, –ve v

Given : x_0 represents the position of the particle at t = 0

Sol.



Q.22 What are various equations for uniform motion of a body?

Sol. Various equations of uniform motion are given below :

(i) $v = \dfrac{s(t_2) - s(t_1)}{t_2 - t_1}$

(ii) $x = s = vt$

(iii) $s(t_2) = s(t_1) + v(t_2 - t_1)$

(iv) $s(t) = s(0) + vt$

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NUMERICALS :

Q.23 A car travels 30km at a uniform speed of 40km/h and the next 30km at a uniform speed of 20km/h find its average speed.

Sol. Time taken on cover 1st 30km $= \frac{\text{Distance}}{\text{Speed}}$

$= \frac{30}{40}$

$= \frac{3}{4}$ hr.

Time taken to cover next 30km $= \frac{30}{20} = \frac{3}{2}$hr.

Total time taken $= \frac{3}{4} + \frac{3}{2}$

$= \frac{3+6}{4} = \frac{9}{4}$hr.

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

$= \frac{30+30}{9/4}$

$= \frac{60+40}{9} = 26.7 \text{ kmhr}^{-1}$

Q.24 A man goes form A to B with a velocity of 20ms^{-1} and comes back from B to A with a velocity of 20ms^{-1}. What is the average velocity of the body. Also calculate the average speed.

Sol. The average velocity is zero because the displacement is zero.

Let distance AB = x

$\therefore$ Time taken to go from A to B $= \frac{x}{20}$sec.

Time taken to come back from B to A $= \frac{x}{40}$sec.

$\therefore$ Total time taken $= \frac{x}{40} + \frac{x}{20}$

$= \left(\frac{3x}{40}\right)$sec.

$\therefore$ Average speed $= \dfrac{\text{Total distance}}{\text{Total time}}$

$= \dfrac{2x}{3x/40} = \dfrac{2\times 40}{3} = 26.7 ms^{-1}$

Q.25 A person covers half of its journey with a speed of $20ms^{-1}$ and the other half with a speed of $30ms^{-1}$. Find the average speed.

Sol. Let total path to be covered is 2x.

Time taken to cover first half $= \dfrac{x}{20}$ sec.

Time taken to cover second half = x/20sec.

$\therefore$ Average speed $= \dfrac{\text{Total distance}}{\text{Total time}}$

$= \dfrac{2x}{\left(\frac{x}{20}+\frac{x}{30}\right)} = \dfrac{2x\times 60}{5x} = 24 ms^{-1}$

Q.26 A runner makes on lap around a 30m track in a time of 30sec. Calculate
(i) average speed (ii) average velocity

Sol. Here distance = 300m
time = 30sec.

(i) Average speed $= \dfrac{\text{Distance}}{\text{Time}}$

$= \dfrac{300}{30} = 10 ms^{-1}$

(ii) In one lap, the displacement of runner is zero.

$\therefore$ Average velocity = zero

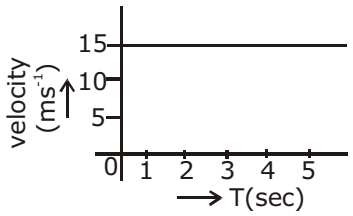
Q.27 The initial position of an object is 20m from the origin. The object starts to move with a uniform speed of $10ms^{-1}$ Find the position after 5sec.

Sol. Here s(0) = 20m
$u = 10\ ms^{-1}$
t = 5sec

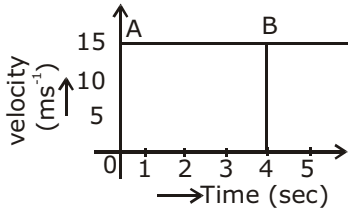
From formula s(t) = s(0) + ut
= 20 + 10 × 5
= 70m

Problems Based on Speed and Velocity

Q.28 The velocity time graph of a body moving with uniform velocity is shown below. Calculate the magnitude of displacement of body in first 4sec.



Sol. Magnitude of displacement



= Area OABC = OA × OC
= (15 – 0) (4 – 0) = 15 × 4 = 60m

Q.29 A woman starts from her home at 9.00am walks with a speed of 5kmh^{-1} on a straight road up to her office 2.5km away. Stays at the office up to 5.00pm and returns home by an auto with a speed of 25kmh^{-1}. Choose suitable scales and plot the x-t graph of the motion.

Sol. Distance of office = 2.5km
Speed of woman = 5kmh^{-1}

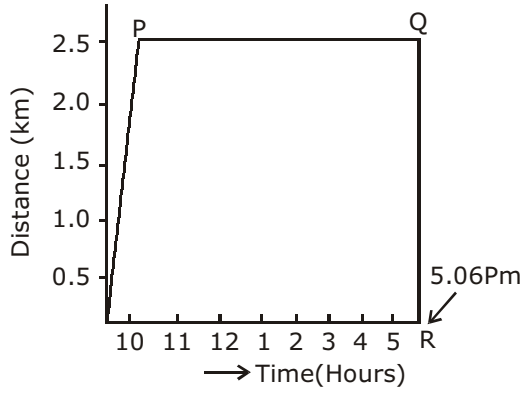
Time taken by woman to reach office t = $\frac{2.5\text{km}}{5\text{kmh}^{-1}} = \frac{1}{2}\text{hr.}$

= 30min.

Women will reach office at 9.30am. This journey is shown by line OP in the graph. She stays in office upto 5.00pm. so the position coordinate will not change with time, and is shown by straight line PQ.
The women returns home by auto with a speed 25km/h

$\therefore$ Time taken by auto = $\frac{2.5\text{ km}}{25\text{ kmh}^{-1}} = \frac{1}{0}\text{hr} = 6\text{min}$

The return journey is shown by line QR.



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Q.30 A man walks on a straight road from his home to a market 2.5km away with a speed of $5kmh^{-1}$. Finding the market closed he instantly turns and walks back home with a speed of $7.5kmh^{-1}$ what is the

(i) magnitude of average velocity.

(ii) average speed of the man over the interval of time.

(i) 0 to 30 min (ii) 0 to 50 min (iii) 0 to 40 min

Sol. Time taken by the man to reach the market = $\frac{2.5}{5}=\frac{1}{2}hr=30min$

Time taken to come back = $\frac{2.5}{7.3}=\frac{1}{3}hr=20min.$

(a) In the time interval 0 to 30 min Distance = displacement = 2.5km

$\therefore$ Average speed = Average velocity = $\frac{2.5}{30/60}=5kmh^{-1}$

(b) In the time interval 0 to 50 min

Distance covered = 2.5 + 2.5 = 5km

Displacement = 0

$\therefore$ Average speed = $\frac{\text{Distance covered}}{\text{Time taken}}$

$=\frac{5}{50/60}=\frac{5\times60}{50}=6kmh^{-1}$

Average sped = $0kmh^{-1}$

(c) In the time interval 0 to 40 in

Distance covered = 2.5 + 1.25

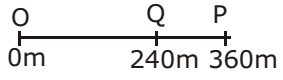
= 3.75 km

Displacement = 1.25km

Average speed = $\frac{3.75}{40}=\frac{60}{1}=5.63kmh^{-1}$

Average velocity = $\frac{3.25}{40}=\frac{60}{1}=1.88kmh^{-1}$

Q.31 A car is moving along a straight line OP (see fig.) It moves from O to P is 18s and returns from P to Q in 6s. What are the average velocity and average speed of the car in going (a) from O to P? and (b) from O to P and back to Q?



Sol. (a) Average velocity, $\vec{v}=\frac{\text{Dispalcement}}{\text{Time interval}}$

or $\vec{v}=\frac{+360}{18s}=+20ms^{-1}$

Average speed = $\frac{\text{Path length}}{\text{Time interval}} = \frac{360\text{m}}{18\text{s}} = 20\text{ms}^{-1}$

Note that, in this case, the average speed is equal to the magnitude of the average velocity.

(b) Average velocity = $\frac{\text{Displacement}}{\text{Time interval}} = \frac{+240\text{m}}{(18+6)\text{s}} = +10\text{ms}^{-1}$

Average speed = $\frac{\text{Path}}{\text{Time interval}} = \frac{OP+PQ}{\Delta t} = \frac{(360+120)\text{m}}{24\text{s}} = 20\text{ms}^{-1}$

Q.32 A bicyclist is travelling along a straight road for the first half time with speed v_1 and for the second half time with speed v_2. What is the average speed of the bicyclist?

Sol. Let t be the total time taken

Distance covered in the first half time = $v_1\left(\frac{t}{2}\right) = \frac{v_1 t}{2}$

Distance covered in the next half time = $v_2\left(\frac{t}{2}\right) = \frac{v_2 t}{2}$

Average speed $v_{av} = \frac{\frac{v_1 t}{2} + \frac{v_2 t}{2}}{t} = \frac{v_1 + v_2}{2}$

Q.33 A person travels along a straight road due east for the first half distance with speed v_1 and the second half distance with speed v_2. What is the average speed of the person?

Sol. Let S be the total distance travelled.

Time taken for the first half distance = $\frac{S/2}{v_1} = \frac{S}{2v_1}$

Time taken for the second half distance = $\frac{S/2}{v_2} = \frac{S}{2v_2}$

Total time taken = $\frac{S}{2v_1} + \frac{S}{2v_2}$; Average speed, v_{av} = $\frac{S}{\frac{S}{2v_1} + \frac{S}{2v_2}} = \frac{2v_1 v_2}{v_1 + v_2}$

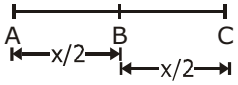
Q.34 A car covers the first half of the distance between two places at a speed of 40kmh^{-1} and second half at 60kmh^{-1} . Calculate the average speed of the car.

Sol. Let the car cover the distance (= x/2) from A to B at a speed of 40kmh^{-1} in time t_1 hour.

Then 40 = $\frac{x/2}{t_1}$ or t_1 = $\frac{x}{80}$ hour

Similarly, the car travels a distance (=x/2) from B to C at a speed of 60kmh^{-1} in time t_2 hour

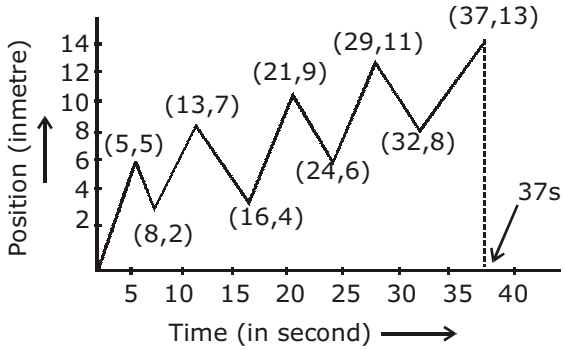
Then $60 = \frac{x/2}{t_2}$ or $t_2 = \frac{x}{120}$ hour



Now, average speed $= \frac{x/2 + x/2}{x/80 + x/120}\text{kmh}^{-1} = \frac{80 \times 120}{200}\text{kmh}^{-1} = 48\text{kmh}^{-1}$

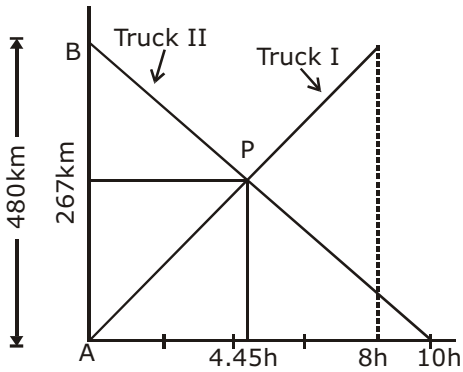
Q.35 A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1m long and requires 1s. Plot of x-t graph of his motion. Determine graphically and otherwise how long the drunkard takes to fall in a pil 13m away from the steps.

Sol. Distance covered in first 8setps = 2k;
Distance covered in first 16 setps = 4m
Distance covered in first 24 setps = 6m;
Distance covered in first 32 setps = 8m
Distance covered in first 37 steps = 13m



Since each step requires one second of time therefore total time is 37 second. We arrive at the same result from the graph shown in fig.

Q.36 Two trucks started at the same time towards each other from cities A and B which are 480km apart. The first truck took eight hours to travel from A to B. The second truck travelled with constant speed and took 10 hrs to travel from B to A. Then at what time from starting do the trucks meet and at what distance from A?



Sol. Let us choose the city A as the reference point.

For first truck (which travels from A to B)

At t = 0, x(0) = 0

At t = 8h, x(t) = 480km

For second truck (which travels from A to B)

At t = 0, x(0) = 480km

At t = 10h, x(t) = 0

With the help of this data for the two trucks, we can plot distance time graphs as shown in fig.

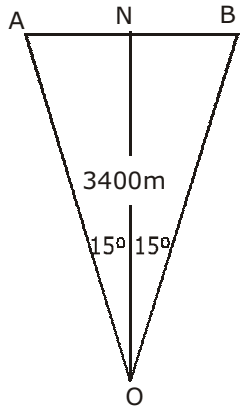
The two straight line graphs intersect at the point P. This point of intersection gives both the position and time of meeting.

The time corresponding to point P is 4.45h while the distance (from A) corresponding to P is 267 km.

Thus, the trucks will meet at a distance of 267km from A, 4.45h after starting.

Q.37 An air craft is flying at a height of 3400m above the ground. If the angle subtended at a ground observation point by the aircraft positions 10sec. apart is 30º. What is the speed of the aircraft.

Sol. Time taken by aircraft from A to B is 10sec



If figure $\angle AON = 15^º$

$\therefore \quad \frac{AN}{ON} = \tan 45^º$

or $AN = ON \tan 45^º$

$= 3400 \times .2679$

$= 910.86m$

$\therefore \quad AB = 2AN$

$= 2 \times 910.86$

$= 1821.72m$

$$\text{Speed of aircraft} = \frac{\text{Distance AB}}{\text{Time taken}}$$

$$= \frac{1821.72}{10}$$

$= 182.17 ms^{-1}$