## CBSE Class 9 Science Important Questions <br> Chapter 8 <br> Motion

## 3 Marks Questions

1. An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example.

Ans. Yes, if an object has moved through a distance it can have zero displacement because displacement of an object is the actual change in its position when it moves from one position to the other. So if an object travels from point $A$ to $B$ and then returns back to point A again, the total displacement is zero.
2. A farmer moves along the boundary of a square field of side10 m in 40 s . What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds?

Ans. Distance covered by farmer in 40 seconds $=4 \times(10) m=40 m$
Speed of the farmer $=$ distance $/$ time $=40 \mathrm{~m} / 40 \mathrm{~s}=1 \mathrm{~m} / \mathrm{s}$.
Total time given in the question $=2 \mathrm{~min} 20$ seconds $=60+60+20=140$ seconds
Since he completes 1 round of the field in 40 seconds so in he will complete 3rounds in 120 seconds (2mins) or 120 m distance is covered in 2 minutes. In another 20seconds will cover another 20 m so total distance covered in $2 \mathrm{~min} 20 \mathrm{sec}=120+20=140 \mathrm{~m}$.
Displacement $=\sqrt{10^{2}}+10^{2}=\sqrt{200}=\sqrt{ } 10 \sqrt{2} m($ as per diagram $)=10 \times 1.414=14.14 \mathrm{~m}$.

3. A train starting from a railway station and moving with uniform acceleration attains a speed $40 \mathrm{~km} \mathrm{~h}^{-1}$ in 10 minutes. Find its acceleration.

Ans. Since the train starts from rest(railway station) $=u=$ zero
Final velocity of train =v= $40 \mathrm{~km} h^{-1}$
$=\frac{(40 \times 1000)}{60 \times 60 \mathrm{~ms}^{-1}}=100 / 9 \mathrm{~ms}^{-1}$
$=11.11 \mathrm{~ms}^{-1}$
time $(t)=10 \mathrm{~min}=10 \times 60=600$ seconds
Since $\mathrm{a}=(\mathrm{v}-\mathrm{u}) / \mathrm{t}=11.11 \mathrm{~ms}^{-1} / 600 \mathrm{sec}=0.018 \mathrm{~m} / \mathrm{s}^{2}$
4. What can you say about the motion of an object whose distance-time graph is a straight-line parallel to the time axis?

Ans. If the object's distance time graph is a straight line parallel to the time axis indicates that with increasing time the distance of that object is not increasing hence the object is at rest i.e. not moving.


Distance-time graph of an object at rest
5. What can you say about the motion of an object if its speed time graph is a straight line parallel to the time axis?

Ans. Such a graph indicates that the object is travelling with uniform velocity.


Time $(t) \longrightarrow$
Speed-time graph of an object moving with uniform speed
6. A train is travelling at a speed of $90 \mathrm{~km} \mathrm{~h}^{-1}$. Brakes are applied so as to produce a uniform acceleration of $-0.5 \mathrm{~m} \mathrm{~s}^{-2}$. Find how far the train will go before itis brought to rest.

Ans. $\mathrm{u}=90 \mathrm{~km} \mathrm{~h}^{-1}=\frac{(90 \times 1000)}{60 \times 60}=25 \mathrm{~ms}^{-1}$
$a=-0.5 \mathrm{~m} \mathrm{~s}^{-2}, \mathrm{v}=0$ (train is brought to rest)
$\mathrm{v}=\mathrm{u}+\mathrm{at}=25+(-0.5) \mathrm{xt}$
$0=25-0.5 \mathrm{x}$
$0.5 \mathrm{t}=25$, or $\mathrm{t}=25 / 0.5=50$ seconds
$s=u t+\frac{1}{2} a t^{2}=25 \times 50+\frac{1}{2} \times(-0.5) \times 50^{2}$
$=1250-625=625 \mathrm{~m}$
7. A stone is thrown in a vertically upward direction with a velocity of $5 \mathrm{~m} \mathrm{~s}^{-1}$. If the acceleration of the stone during its motion is $10 \mathrm{~m} \mathrm{~s}^{-2}$ in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?

Ans. $u=5 \mathrm{~m} \mathrm{~s}^{-1}, a=-10 \mathrm{~m} \mathrm{~s}^{-2}$
$\mathrm{v}=0$ (since at maximum height its velocity will be zero)
$\mathrm{v}=\mathrm{u}+\mathrm{at}=5+(-10) \times t$
$0=5-10 t$
$10 t=5$, or, $t=5 / 10=0.5$ second.
$S=u t+\frac{1}{2} a t^{2}=5 \times 0.5+\frac{1}{2} \times(-10) \times 0.5^{2}$
$=2.5-1.25=1.25 \mathrm{~m}$
8. Derive the second equation of motion $S=u t+\frac{1}{2} a t^{2}$ graphically?

Ans. let at time $\mathrm{T}=0$ body moves with initial velocity u and at time ' t ' body has final velocity ' $v$ ' and un time ' $t$ ' it covers a distance's.
$\mathrm{AC}=\mathrm{v}, \mathrm{AB}=\mathrm{u}, \mathrm{OA}=\mathrm{t}, \mathrm{DB}=\mathrm{OA}=\mathrm{t}, \mathrm{BC}=\mathrm{AC}-\mathrm{AB}=\mathrm{V}-\mathrm{u}$
Area under a v-t curve gives displacement so,
$S=$ Area of $\Delta \mathrm{DBC}+$ Area of rectangle OABD $\rightarrow$ (i)
Area of $\triangle \mathrm{DBC}=\frac{1}{2} \times$ Base $\times$ Height $\Rightarrow \frac{1}{2} \times \mathrm{DB} \times \mathrm{BC}$
$=\frac{1}{2} \times \mathrm{t} \times(\mathrm{v}-\mathrm{u}) \rightarrow(\mathrm{ii})$
velocity
Area of rectangle OABD $=$ length $\times$ Breadth
$=O A \times B A$
$=\mathrm{t} \times \mathrm{u} \rightarrow$ (iii)
$\mathrm{S}=\mathrm{ut}+\frac{1}{2} \times \mathrm{t} \times(\mathrm{v}-\mathrm{u})$
$S=u t+\frac{1}{2} t \times$ at $(\therefore$ use $V-u=a t)$
$S=u t+\frac{1}{2} a t^{2}$
9. A car moving with a certain velocity comes to a halt if the retardation was $5 \mathrm{~m} / \mathrm{s}^{2}$, find the initial velocity of the car?

Ans. V=0 (comes to rest) V= final velocity
$S=62.5 \mathrm{~m}$
$a=-5 m / s^{2}$ (retardation)
$\mathrm{U}=$ ?

From $3^{\text {rd }}$ equation of motion,
$v^{2}-u^{2}=2 a s$
$O^{2}-u^{2}=2 \times(-5) \times 62.5$
$-u^{2}=-10 \times 62.5$
$u^{2}=625$,
$\mathrm{u}=\sqrt{625}[\mathrm{u}=25 \mathrm{~m} / \mathrm{s}]$
10. Two cars $A$ and $B$ are moving along in a straight line. Car $A$ is moving at a speed of 80 KMph while car $B$ is moving at a speed 50 KMph in the same direction, find the

## magnitude and direction of

(a) tive $v$ the relative of car $A$ with respect to $B$

The relative velocity of car $B$ with respect to $A$.

Ans. (a) Velocity of car $\mathrm{A}=80 \mathrm{KMph}$

Velocity of Car B = - 50 kmph
(-ve sign indicates that Car B is moving in opposite direction to Car A )

Relative velocity of car A with respect to B
$=$ velocity of car A $+(-$ velocity of car B)
$=80+(-(-50))$
$=80+50$
=+130KMph
+130 KM ph shows that for a person in car B, car A will appear to move in the same direction with speed of sum of their individual speed.
(b) Relative velocity of car B with respect to A
$=$ velocity of car B+ (- velocity of car A)
$=-50+(-80)$
$=-130 \mathrm{kmph}$
$\rightarrow$ It shows that car B will appear to move with 130 kmph in opposite direction to car A
11. A ball starts from rest and rolls down 16 m down an inclined plane in 4 s .
(a) What is the acceleration of the ball?
(b) What is the velocity of the ball at the bottom of the incline?

Ans. $u=$ initial velocity $=0($ body starts from rest)
$\mathrm{S}=$ distance $=16 \mathrm{~m}$
$\mathrm{T}=$ time $=4 \mathrm{~s}$
(i) From, $s=u t+\frac{1}{2} a t^{2}$
$16=0 \times t+\frac{1}{2} a \times(4)^{2}$
$16=\frac{1}{2} \times \mathrm{a} \times 16$
$\frac{16 \times 2}{16}=a$
$\left[2 m / s^{2}=a\right]$
(ii) From, v= u +at
$\mathrm{v}=0+2 \times 4$
[ $\mathrm{v}=8 \mathrm{~m} / \mathrm{s}$ ]
12. Two boys $A$ and $B$, travel along the same path. The displacement - time graph for their journey is given in the following figure.

(a) How far down the road has B travelled when A starts the journey?
(b) Without calculation, the speed, state who is traveling faster A or B?
(c) What is the speed of $A$ ?
(d) What is the speed of $B$ ?
(e) Are the speed of A and B uniform?
(f) What dose point $X$ on the graph represent?
(g) What is the speed of approach of A towards B?

What is the speed of separation of $A$ from $B$ ?

Ans. (a) When A starts his journey at 4 sec , B has already covered a distance of 857 m
(b) A travels faster than B because A starts his journey late but crosses B and covers more distance then $B$ in the same time as $B$
(c) Speed of $\mathrm{A}=\frac{\text { Dis } \tan \text { ce covered }}{\text { time taken }}$

Let at $\mathrm{t}=12 \mathrm{~min}$, distance covered $=3500 \mathrm{~m}$
$=\frac{3500}{12}=375 \mathrm{~m} / \mathrm{min}$
(d) Speed of $\mathrm{B}=\frac{\text { dis } \tan \text { ce covered }}{\text { time taken }}$
$V_{B}=\frac{3000}{12}=214 \mathrm{~m} / \mathrm{min}$
(e) Speed of approach of A towards B $=375 \mathrm{~m} / \mathrm{min}-214 \mathrm{~m} / \mathrm{min}$
$=161 \mathrm{~m} / \mathrm{min}$
(f) Speed of separation of A from $B=161 \mathrm{~m} / \mathrm{min}$.
13. A body is dropped from a height of 320 m . The acceleration due to the gravity is
$10 \mathrm{~m} / \mathrm{s}^{2}$ ?
(a) How long does it take to reach the ground?
(b) What is the velocity with which it will strike the ground?

Ans. Height $=\mathrm{h}$
Distance $=\mathrm{s}=320 \mathrm{~m}$
Acceleration due to gravity $=g=10 \mathrm{~m} / \mathrm{s}^{2}$
Initial velocity $=\mathrm{u}=0$
(a) from s $=u t+\frac{1}{2} a t^{2}$
$h=u t \times \frac{1}{2} g t^{2}$
$320=0 \times t+\frac{1}{2} \times 10 \times t^{2}$
$\frac{320 \times 2}{10}=t^{2}$
$64=t^{2}$
$t=8 \mathrm{sec}$
(b) from $v=u+a t$
$v=0+10 \times 8$
$v=80 \mathrm{~m} / \mathrm{s}$
14. Derive third equation of motion $v^{2}-u^{2}=2 a s$ numerically?

Ans. We know;
$v=u+a t$
$s=u t+\frac{1}{2} a t^{2}$

Where, v = final velocity
$\mathrm{u}=$ initial velocity
$\mathrm{a}=$ acceleration
$\mathrm{t}=$ time
$s=$ distance

From equation (i) $\mathrm{t}=\frac{v-u}{a}$

Put the value of $t$ in equation (ii)
$s=u \times \frac{v-u}{a}+\frac{1}{2} a \times \frac{v-u}{a}$
$s=\frac{u v-u^{2}}{a}+\frac{1}{2} a \times \frac{v^{2}+u^{2}-2 u v}{a^{2}}$
$s=\frac{u v-v^{2}}{a}+\frac{1}{2} \times \frac{v^{2}+u^{2}-2 v u}{a}$
$s=\frac{2 u v-2 u^{2}+v^{2}+u^{2}-2 v u}{2 a}$
$s=\frac{v^{2}-u^{2}}{2 a}$
$2 a s=v^{2}-u^{2}$
$v^{2}=u^{2}+2 a s$
15. The velocity time graph of runner is given in the graph.
(a) What is the total distance covered by the runner in $\mathbf{1 6 s}$ ?
(b) What is the acceleration of the runner at $t=11 s ?$


Ans. (a) We know that area under v-t graph gives displacement:
So, Area $=$ distance $=s=$ area of triangle + area of rectangle
Area of triangle $=\frac{1}{2} \times$ base $\times$ height
$=\frac{1}{2} \times 6 \times 10$
$=30 \mathrm{~m}$

Area of rectangle $=$ length $\times$ breadth
$=(16-6) \times 10$
$=10 \times 10$
$=100 \mathrm{~m}$

Total area $=180 \mathrm{~m}$

Total distance $=180 \mathrm{~m}$
(b) Since at $\mathrm{t}=11 \mathrm{sec}$, particles travels with uniform velocity so, there is no change in velocity hence acceleration $=$ zero.
16. A boy throws a stone upward with a velocity of $60 \mathrm{~m} / \mathrm{s}$.
(a) How long will it take to reach the maximum height $\left(\mathrm{g}=-10 \mathrm{~m} / \mathrm{s}^{2}\right)$ ?
(b) What is the maximum height reached by the ball?
(c) How long will it take to reach the ground?

Ans. $u=60 \mathrm{~m} / \mathrm{s} ; g=-10 \mathrm{~m} / \mathrm{s}^{2} ; \mathrm{v}=0$
(a) The time to reach maximum height is;
$v=u+a t=u+g t$
$0=60-10 t$
$t=\frac{60}{10}=6 s$
(b) The maximum height is;
$v^{2}=u^{2}+2 g s$
$s=-\frac{u^{2}}{2 g}=\frac{60^{2}}{2 \times 10}$
$=180 \mathrm{~m}$
(c) The time to reach top is equal to time taken to reach back to ground. Thus, time to reach the ground after reaching top is 6 s Or the time to reach the ground after throwing is $6+6$ $=12 \mathrm{~s}$.
17. The displacement $x$ of a particle in meters along the $x$ - axis with time ' $t$ ' in seconds according to the equation-
$X=20 m+\left(\frac{12 m}{s}\right) t$
(a) draw a graph if $x$ versus $t$ for $t=0$ and $t=5 \sec$
(b) What is the displacement come out of the particles initially?
(c) What is slope of the graph obtained?

Ans. $X=20 m+(12) t$
(i) At $t=0$
$\mathrm{X}=20+12 \times 0=12 \mathrm{~m}$
(ii) At $\mathrm{t}=1$
$\mathrm{X}=20+12=32 \mathrm{~m}$
(iii) At $t=2$
$\mathrm{X}=20+24=44 \mathrm{~m}$
(iv) At $t=5$
$\mathrm{X}=20+12 \times 5=72 \mathrm{~m}$

(b) At $\mathrm{T}=0$ (initially)

Displacement $=20 \mathrm{~m}$.
(c) Slope $=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}=\frac{72-44}{5-2}=\frac{28}{3}$
$=9.3 \mathrm{~m} / \mathrm{s}$
18. The velocity of a body in motion is recorded every second as shown-

| lime (S) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| velocly (mis) | 62 | 54 | 48 | 42 | 36 | 30 | 24 | 18 | 12 | 6 | 0 |

calculate the -
(a) Acceleration
(b) distance travelled and draw the graph.

Ans. (a) Acceleration =slope of the velocity time graph
$\mathrm{a}=\frac{V_{2}-V_{1}}{t_{2}-t_{1}}$
$a=\frac{54-24}{1-6}=\frac{30}{-5}=-6 \mathrm{~m} / \mathrm{s}^{2}$
(b) Distance $\Rightarrow S=u t+\frac{1}{2} a t^{2}$
$=60 \times 10+\frac{1}{2}(-6) \times(10)^{2}$
$=600-300=300 \mathrm{~m}$
(c)

19. Draw the graph for uniform retardation -
(a) position - time graph
(b) velocity - time
(c) Acceleration- time

Ans. (1) Position - time

(2) Velocity - time

(3) Acceleration- time

20. The displacement - time graph for a body is given. State whether the velocity and acceleration of the body in the region $B C, C D, D E$ and $E F$ are positive, negative or Zero.


Ans. (i) For $A B$, the curve is upward stopping i.e. slope is increasing so velocity is positive and remains same so, $\mathrm{V}=+$ ve but $\mathrm{a}=0$
(ii) For BC , curve has still has +ve slope so, $\mathrm{V}=+\mathrm{ve}$ but velocity is decreasing wrt time so, a=negative
(iii) For CD, both velocity and acceleration are Zero because slope is Zero.
(iv) For DE, velocity is the (v is increasing wrt time) and so is acceleration is +ve.
(v) For EF, velocity is +ve (positive slope of x-t graph) but acceleration is Zero because velocity remains some with time.

| AB | BC | CD | DE | EF |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| V | +ve | +ve | 0 | +ve | +ve |
| A | 0 | -ve | 0 | +ve | 0 |

## 21. Derive the third equation of motion $-v^{2}-u^{2}=2$ as graphically?

Ans. Let at time $t=0$, body moves with initial velocity $u$ and time at ' $t$ ' has final velocity ' $v$ ' and in time ' $t$ ' covers a distance ' $s$ '


Area under v-t graph gives displacement
$S=$ Area of $\triangle \mathrm{DBC}+$ Area of rectangle OABD
$\mathrm{S}=\frac{1}{2} \times$ base $\times$ height + length $\times$ breadth
$S=\frac{1}{2} \times D B \times B C+O A \times A B$
$S=\frac{1}{2} \times t \times(v-u)+t \times u \rightarrow(\mathrm{i})$
Now, v-u = at
$\frac{v-u}{a}=t$
Put the value of ' $t$ ' in equation (i)
$S=\frac{1}{2} \times(v-u) \frac{(v-u)}{a}+u \times\left(\frac{(v-u)}{a}\right)$
$S=\frac{(v-u)^{2} 2 u(v-u)}{2 a}$
$S=\frac{v^{2}+u^{2}-2 u v+2 u v-2 u^{2}}{2 a}$
$S=\frac{v^{2}-u^{2}}{2 a}$
$2 a s=v^{2}-u^{2} \Rightarrow$ third equation of motion

