# RELATIVE MOTION

## Contents



## Syllabus

Relative Velocity

# RELATIVE MOTION

## RELATIVE VELOCITY :

Velocity of 'A' relative to 'B' is given by $\vec{V}_{AB}=\vec{V}_A-\vec{V}_B$ .

$\vec{V}_{AB}$ refers to the velocity which 'A' appears to have as seen by B. The above idea of 1 dimensional relative motion can be extended to motion in 2 dimensions.

(a) For crossing a river in minimum possible time, the velocity of the swimmer relative to the river should be perpendicular to the river flow.

(b) If an athelete is running, his clothes will be furling in the direction of the velocity of the wind relative to him self.

(c) If you do not want to get drenched in a rain, you should hold the umbrella in a direction opposite to the velocity of the rain relative to your self.

(d) Two particles, 1 and 2, move with constant velocities $v_1$ and $v_2$. At the initial moment their radius vectors are equal to $r_1$ and $r_2$. For the two particles to collide, the relative velocity of 1 with respect to 2 should be directed towards 1 as seen by 2.

# EXERCISE # 1

## PART - I : OBJECTIVE QUESTIONS

** Marked Questions are having more than one correct option.*

### Section : (A) Relative motion

**A-1.** A train is standing on a platform, a man inside a compartment of a train drops a stone. At the same instant train starts to move with constant acceleration. The path of the particle as seen by the person who drops the stone is :
(A) parabola
(B) straight line for sometime & parabola for the remaining time
(C) straight line
(D) variable path that cannot be defined.

**A-2.** Two trains A & B 100 km apart are travelling towards each other on different tracks with starting speed of 50 km/h for both. The train A accelerates at 20 km/h$^2$ and the train B retards at the rate 20 km/h$^2$ . The distance covered by the train A when they cross each other is :
(A) 45 km (B) 55 km (C) 65 km (D) 60 km

**A-3.** Two particles are moving with velocities $v_1$ and $v_2$. Their relative velocity is the maximum, when the angle between their velocities is :
(A) zero (B) $\pi/4$ (C) $\pi/2$ (D) $\pi$

**A-4.** A car A is going north east at 80 kmh–1 and another car B is going south east with a velocity of 60 kmh$^{-1}$. The velocity of A relative to B makes an angle with the north equal to

(A) $\tan^{-1}\left(\frac{2}{7}\right)$ (B) $\tan^{-1}\left(\frac{7}{2}\right)$ (C) $\tan^{-1}(7)$ (D) $\tan^{-1}\left(\frac{1}{7}\right)$..

**A-5.** A coin is released inside a lift at a height of 2 m from the floor of the lift. The height of the lift is 10 m. The lift is moving with an acceleration of 11 m/s$^2$ downwards. The time after which the coin will strike with the lift is :

(A) 4 s (B) 2 s (C) $\frac{4}{\sqrt{21}}$ s (D) $\frac{2}{\sqrt{11}}$ s

**A-6.** A ship is travelling due east at 10 km/h. A ship heading 30° east of north is always due north from the first ship. The speed of the second ship in km/h is -

(A) $20\sqrt{2}$ (B) $20\sqrt{3/2}$ (C) 20 (D) $20/\sqrt{2}$

**A-7.** Three ships A, B & C are in motion. The motion of A as seen by B is with speed v towards north – east. The motion of B as seen by C is with speed v towards the north – west. Then as seen by A, C will be moving towards
(A) north (B) south (C) east (D) west

**A-8.** A man in a balloon, throws a stone downwards with a speed of 5 m/s with respect to balloon. The balloon is moving upwards with a constant acceleration of 5 m/s$^2$. Then velocity of the stone relative to the man after 2 second is :

(A) 10 m/s

(B) 30 m/s

(C) 15 m/s

(D) 35 m/s

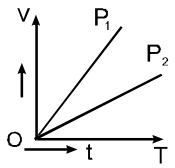
**A-9.** Three stones A, B and C are simultaneously projected from same point with same speed. A is thrown upwards, B is thrown horizontally and C is thrown downwards from a building. When the distance between stone A and C becomes 10 m, then distance between A and B will be :

(A) 10 m (B) 5 m (C) $5\sqrt{2}$ m (D) $10\sqrt{2}$ m

**A-10.** A body is thrown up in a lift with a velocity u relative to the lift and the time of flight is found to be 't '. The acceleration with which the lift is moving up is :

(A) $\frac{u - gt}{t}$ (B) $\frac{2u - gt}{t}$ (C) $\frac{u + gt}{t}$ (D) $\frac{2u + gt}{t}$

**A-11.** Shown in the figure are the velocity time graphs of the two particles $P_1$ and $P_2$. Which of the following statements about their relative motion is true?
Magnitude of their relative velocity : (consider 1-D motion)



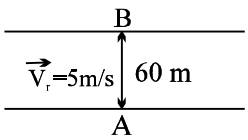

(A) is zero (B) is non-zero but constant
(C) continuously decreases (D) continuously increases

## Section : (B) Relative motion in river flow & Air flow

**B-1.** The speed of boat is 5 km/h in still water. It crosses a river of width 1 km along shortest possible path in 15 min. The velocity of river water is

(A)1 km/h (B) 3 km/h (C) 4 km/h (D) 5 km/h

**B-2.** A man is crossing a river flowing with velocity of 5 m/s. He reaches a point directly across at a distance of 60 m in 5 sec. His velocity in still water should be




(A) 12 m/s (B) 13 m/s
(C) 5 m/s (D) 10 m/s

**B-3.** If speed of water in river is 4 m/s and speed of swimmer with respect to water is 3 m/s, then in which direction the swimmer must swim so that he will reach directly opposite end?

(A) 127° with direction of river flow
(B) 90° with direction of river flow
(C) 143° with direction of river flow
(D) Swimmer will never reach directly opposite end

**B-4.** A boat can go across a lake and return in time $T_0$ at a speed V. On a rough day there is uniform current at speed u to help the onward journey and impede the return journey. If the time taken to go across and return on the rough day be T, then $T/T_0$ =

(A) $1 - \frac{u^2}{V^2}$ (B) $\frac{1}{1-\frac{u^2}{V^2}}$ (C) $1 + \frac{u^2}{V^2}$ (D) $\frac{1}{1+\frac{u^2}{V^2}}$

**B-5.** To cross the river in shortest distance, a swimmer should swim making angle $\theta$ with the upstream. What is the ratio of the time taken to swim across in the shortest time to that in swimming across over shortest distance. [Assume speed of swimmer in still water is greater than the speed of river flow

(A) $\cos\theta$ (B) $\sin\theta$ (C) $\tan\theta$ (D) $\cot\theta$

**B-6.** A man crosses the river perpendicular to river flow in time t seconds and travels an equal distance down the stream in T seconds. The ratio of man's speed in still water to the speed of river water will be:

(A) $\frac{t^2 - T^2}{t^2 + T^2}$ (B) $\frac{T^2 - t^2}{T^2 + t^2}$ (C) $\frac{t^2 + T^2}{t^2 - T^2}$ (D) $\frac{T^2 + t^2}{T^2 - t^2}$

## Section : (C) Relative motion in Rain and wind

**C-1.** When a person walks on a straight road with a speed 10 km/h, rain appears to fall verticlly downward. As he stops, the rain appears to fall at an angle 30° with vertical. The speed of rain with respect to the person.

(A) 20 km/hr (B) $10\sqrt{3}$ km/hr (C) 10 km/hr (D) $20\sqrt{3}$ km/hr

**C-2.** An aeroplane is to go along straight line from A to B, and back again. The relative speed with respect to wind is V.. The wind blows perpendicular to line AB with speed $\upsilon$. The distance between A and B is $\ell$. The total time for the round trip is:

(A) $\frac{2\ell}{\sqrt{V^2 - v^2}}$ (B) $\frac{2\,v\ell}{V^2 - v^2}$ (C) $\frac{2\,V\,\ell}{V^2 - v^2}$ (D) $\frac{2\ell}{\sqrt{V^2 + v^2}}$

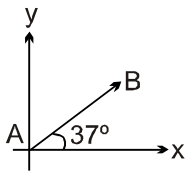
**C-3.** A flag is mounted on a car moving due North with velocity of 20 km/hr. Strong winds are blowing due East with velocity of 20 km/hr. The flag will point in direction

(A) East (B) North - East (C) South - East (D) South - West

**C-4.** Rain is falling vertically with a speed of 20 $ms^{-1}$ relative to air. A person is running in the rain with a velocity of 5 $ms^{-1}$ and a wind is also blowing with a speed of 15 $ms^{-1}$ (both towards east). Find the angle with the vertical at which the person should hold his umbrella so that he may not get drenched.

(A) $\tan^{-1}\sqrt{2}$ (B) $\tan^{-1}\left(\frac{1}{2}\right)$ (C) $\tan^{-1}(2)$ (D) 45°

**C-5.** A butterfly is flying with velocity $10\hat{i} + 12\hat{j}$ m/s and wind is blowing along x axis with velocity u. If butterfly starts motion from A and after some time reaches point B, find the value of u.



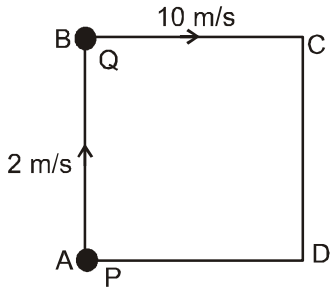

(A) 2 m/s (B) 6 m/s (C) 4 m/s (D) 3m/s

**C-6.** Raindrops are falling vertically with a velocity of 10 m/s. To a cyclist moving on a straight road the raindrops appear to be coming with a velocity of 20 m/s. The velocity of cyclist is :

(A) 10 m/s (B) $10\sqrt{3}$ m/s (C) 20 m/s (D) $20\sqrt{3}$ m/s

## Section : (D) Velocity of separation & approach

**D-1.** Two men P & Q are standing at corners A & B of square ABCD of side 8 m. They start moving along the track with constant speed 2 m/s and 10 m/s respectively. The time when they will meet for the first time, is equal to :

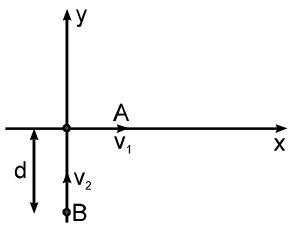



(A) 2 sec (B) 3 sec (C) 1 sec (D) 6 sec

**D-2.** For two particles A and B, given that $\vec{r}_A = 2\hat{i} + 3\hat{j}$, $\vec{r}_B = 6\hat{i} + 7\hat{j}$, $\vec{v}_A = 3\hat{i} - \hat{j}$ and $\vec{v}_B = x\hat{i} - 5\hat{j}$. What is the value of x if they collide.

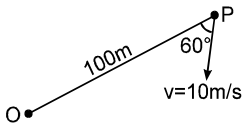
(A) 1 (B) – 1 (C) 2 (D) –2

**D-3.** Two particles A and B move with velocities $v_1$ and $v_2$ respectively along the x & y axis. The initial separation between them is 'd' as shown in the fig. Find the least distance between them during their motion.




(A) $\frac{d.v_1^2}{v_1^2 + v_2^2}$ (B) $\frac{d.v_2^2}{v_1^2 + v_2^2}$ (C) $\frac{d.v_1}{\sqrt{v_1^2 + v_2^2}}$ (D) $\frac{d.v_2}{\sqrt{v_1^2 + v_2^2}}$

**D-4.** P is a point moving with constant speed 10 m/s such that its velocity vector always maintains an angle 60° with line OP as shown in figure (O is a fixed point in space). The initial distance between O and P is 100 m. After what time shall P reach O.



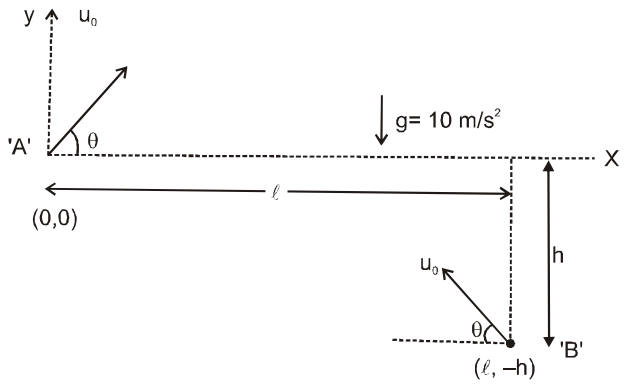

(A) 10 sec. (B) 15 sec. (C) 20 sec. (D) $20\sqrt{3}$ sec

# PART - II : MISLLANEOUS QUESTIONS

## COMPREHENSION TYPE

**Comprehensions # 1 :**

Two particles 'A' and'B' are projected in the vertical plane with same intial velocity $u_0$ from point (0, 0) and ($\ell$, - h) towards each other as shown in figure at t = 0.




**1.** The path of particle 'A' with respect to particle 'B' will be :

(A) parabola (B) straight line parallel to x - axis.

(C) straight line parallel to y-axis (D) none of these.

**2.** Minimum distance between particle A and B during motion will be :

(A) $\ell$ (B) h (C) $\sqrt{\ell^2 + b^2}$ (D) $\ell$ + h

**3.** The time when separation between A and B is minimum is :

(A) $\frac{x}{u_0 \cos\theta}$ (B) $\sqrt{\frac{2h}{g}}$ (C) $\frac{\ell}{2u_0 \cos\theta}$ (D) $\frac{2\ell}{u_0 \cos\theta}$

**Comprehensions # 2 :**

Raindrops are falling with a velocity $10\sqrt{2}$ m/s making an angle of 45° with the vertical. The drops appear to be falling vertically to a man running with constant velocity. The velocity of rain drops change such that the rain drops now appear to be falling vertically with $\sqrt{3}$ times the velocity it appeared earlier to the same person running with same velocity.

**4.** The magnitude of velocity of man with respect to ground is :

(A) $10\sqrt{2}$ m/s (B) $10\sqrt{3}$ m/s (C) 20 m/s (D) 10 m/s

**5.** After the velocity of rain drops change, the magnitude of velocity of raindrops with respect to ground is:

(A) 20 m/s (B) $20\sqrt{3}$ (C) 20 m/s (D) $10\sqrt{3}$ m/s

**6.** The angle (in degrees) between the initial and the final velocity vectors of the raindrops with respect to the ground is :

(A) 8 (B) 15 (C) 22.5 (D) 37

## MATCH THE COLUMN

**Match the Column :**

**7.** Two particles A and B moving in x-y plane are at origin at t = 0 sec. The initial velocity vectors of A and B are $\bar{u}_A = 8\ \hat{i}$ m/s and $\bar{u}_B = 8\ \hat{j}$ m/s. The acceleration of A and B are constant and are $\bar{a}_A = -\ 2\ \hat{i}$ m/s$^2$ and $\bar{a}_B = -\ 2\ \hat{j}$ m/s$^2$. Column I gives certian statements regarding particle A and B. Column II gives corresponding results. Match the statements in column I with corresponding results in Column II.

| **Columns I** | | **Column II** |
|---|---|---|
| (A) | The time (in seconds) at wich velocity of A relative to B is zero | (p) $16\sqrt{2}$ |
| (B) | The distance (in metres) betwen A and B when their relative velocity is zero. | (q) $8\sqrt{2}$ |
| (C) | The time (in seconds) after t = 0 sec. at which A and B are at same position | (r) 8 |
| (D) | The magnitude of relative velocity of A and B at the instant they are at same position. | (s) 4 |
| | | (t) 6 seconds |

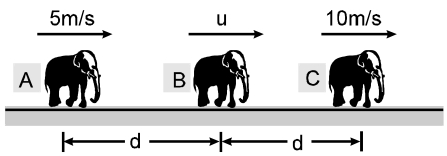
# EXERCISE # 2

## PART - I : MIXED OBJECTIVE

** **Marked Questions are having more than one correct option.***

### Single Correct Answer Type :

**1.** Three elephants A, B and C are moving along a straight line with constant speed in same direction as shown in figure. Speed of A is 5 m/s and speed of C is 10 m/s. Initially separation between A & B is 'd' and between B & C is also d. When 'B' catches 'C' separation between A & C becomes 3d. Then the speed of B will be -




(A) 7.5 m/s (B) 15 m/s (C) 20 m/s (D) 5 m/s

**2.** A projectile A is projected from ground. An observer B running on ground with uniform velocity of magnitude 'v' observes A to move along a straight line. The time of flight of A as measured by B is T. Then the range R of projectile on ground is :

(A) R = vT (B) R < vT

(C) R > vT (D) Information insufficient

**3.** A swimmer crosses a river with minimum possible time 10 second. And when he reaches the other end starts swimming in the direction towards the point from where he started swimming. Keeping the direction fixed the swimmer crosses the river in 15 sec. The ratio of speed of swimmer with respect to water and the speed of river flow is (Assume constant speed of river & swimmer) :

(A) $\frac{3}{2}$ (B) $\frac{9}{4}$ (C) $\frac{2}{\sqrt{5}}$ (D) $\frac{\sqrt{5}}{2}$

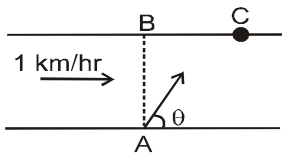
**4.** Two points P and Q move in same plane such that the relative acceleration of P with respect to Q is zero. They are moving such that the distance between them is decreasing. Pick the correct statement for P and Q to collide
(A) The line joining P and Q should not rotate.
(B) The line joining P and Q should rotate with constant angular speed
(C) The line joining P and Q should rotate with variable angular speed
(D) All the above statement are correct

**5.** Wind is blowing in the north direction at speed of 2 m/s which causes the rain to fall at some angle with the vertical. With what velocity should a cyclist drive so that the rain appears vertical to him :
(A) 2 m/s south (B) 2 m/s north (C) 4 m/s west (D) 4 m/s south

**6.** A bucket is placed in the open where the rain is falling vertically. If a wind begins to blow horizontally at double the velocity of the rain, how will be rate of filling of the bucket change?
(A) Remain unchanged (B) Doubled (C) Halved (D) Become four times

## Multiple Correct Answer(s) Type

**7.** A river is flowing with a speed of 1 km/hr. A swimmer wants to go topoint 'C' starting from 'A'. he swims with a speed of 5 km/hr, at angle $\theta$, w.r.t. the river. If AB = BC = 400 m. Then :

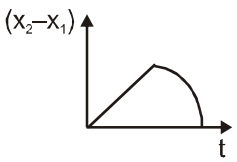


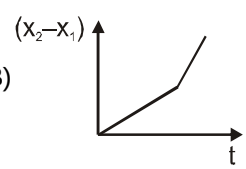

(A) the value of $\theta$ is 53° (B) time taken by the man is 6 min
(C) time taken by the man is 8 min (D) the value of $\theta$ is 45°

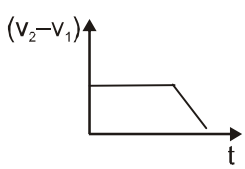
**8.** A ball is thrown vertically upward (relative to the train) in a compartment of a moving train.
(A) The ball will maintain the same horizontal velocity as that of the person (or the compartment) at the time of throwing.
(B) If the train is accelerating then the horizontal velocity of the ball will be different from that of the train velocity, at the time of throwing.
(C) If the ball appears to be moving backward to the person sitting in the compartment it means that speed of the train is increasing.
(D) If the ball appears to be moving ahead of the person sitting in the compartment it means the train's motion is retarding.

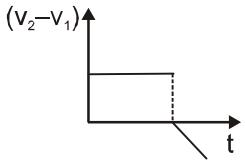
**9.** A swimmer who can swim in a river with speed mv (with respect to still water) where v is the velocity of river current, jumps into the river from one back to cross the river.
(A) If $m \leq 1$ he can not reach a point on other bank directly opposite to his starting point.
(B) If $m < 1$ he can not cross the river.
(C) If $m > 1$ he can reach a point on other bank.
(D) He can reach the other bank at some point, whatever be the value of m.

**10.** Two stones are thrown vertically upwards simultaneously from the same point on the ground with initial speed $u_1 = 30$ m/sec and $u_2 = 50$ m/sec. Which of the curve represents correct variation (for the time interval in which both reach the ground) of
$(x_2 - x_1)$ = the relative position of second stone with respect to first with time (t).
$(v_2 - v_1)$ = the relative velocity of second stone with respect to first with time (t).
Assume that stones do not rebound after hitting :

(A) 

(B) 

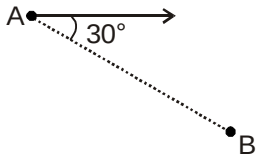
(C) 

(D) 

## PART - II : SUBJECTIVE QUESTIONS

**1.** Men are running along a road at 15 km/h behind one another at equal intervals of 20 m. Cyclists are riding in the same direction at 25 km/h at equal intervals of 30 m. At what speed in km/h an observer travelling along the road in opposite direction so that whenever he meets a runner he also meets a cyclist? (neglect the size of cycle)

**2.** A particle A is moving with a constant velocity of 10 m/sec. Another particle B is moving with a constant but unknown velocity. At an instant, the line joining A and B makes an angle of 30° with velocity of A. Find the minimum possible magnitude of velocity of B in m/s, if they collide after some time. (see figure)




**3.** A motorboat going down stream over come a float at a point M which is fixed with respect to ground. 60 minutes later it turned back and after some time passed the float at a distance of 6 km from the point M. Find the velocity of the stream assuming a constant velocity for the motorboat in still water in km/h.

## EXERCISE # 3

## PART-I IIT-JEE (PREVIOUS YEARS PROBLEMS)

* ***Marked Questions are having more than one correct option.***

**1.** A river is flowing from west to east at a speed of 5 metre per minute. A man on the south bank of the river, capable of swimming at 10 metre per minute in still water, wants to swim across the river in the shortest time. He should swim in a direction : **[ JEE-1983, 1 ]**

(A) due north (B) $30^0$ east of north

(C) $30^0$ west of north (D) $60^0$ east of north

**2.** A boat which has a speed of 5 km/hr in still water crosses a river of width 1 km along the shortest possible path in 15 minutes. The velocity of the river water in km/hr is : **[ JEE-1988, 2 ]**

(A) 1 (B) 3 (C) 4 (D) $\sqrt{41}$

**3.** An aeroplane is flying vertically upwards with a uniform speed of 500 m/s. When it is at a height of 1000 m above the ground a shot is fired at it with a speed of 700 m/s from a point directly below it. What should be the uniform acceleration of the aeroplane now so that it may escape from being hit?

($g = 10\ m/s^2$) **[ REE-1994, 6 ]**

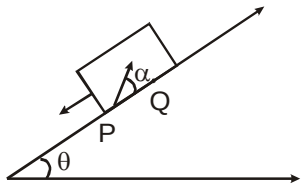
**4.** The width of a river is 25 m and in it water is flowing with a velocity of 4 m/min. A boatman is standing on the bank of the river. He wants to sail the boat to a point at the other bank which is directly opposite to him. In what time will he cross the river, if he can sail the boat at 8 m/min, relative to the water. **[ REE-1995, 6 ]**

**5.** Two guns situated on the top of a hill of height 10m fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time. One gun fires horizontaly and other fires upwards at an angle of 60º with the horizontal. The shots collide in air at point P. Find : **[ JEE '96, 5 ]**

(a) The time interval between the firings and

(b) the coordinates of the point P. Take origin of the coordinate system at the foot of the hill right below the muzzle and trajectories in x-y plane

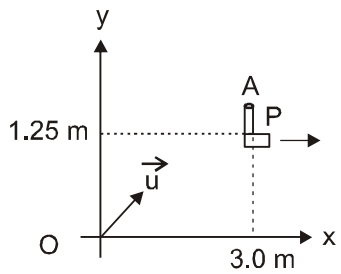
**6.** A large heavy box is sliding without friction down a smooth plane of inclination $\theta$ From a point P on the bottom of the box, The initial speed of the particle with respect to the box is u and the direction of projection makes an angle $\alpha$ with the bottom as shown in the figure :



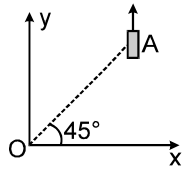

(a) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands ( Assume that the particle does not hit any other surface of the box. Neglect air resistance.) **[JEE-1998, 5 + 3/120]**

(b) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected.

**7.** An object A is kept fixed at the point x = 3 m and y = 1.25 m on a plank P raised above the ground. At time t = 0 the plank starts moving along the + x direction with an acceleration 1.5 m/s$^2$. At the same instant a stone is projected from the origin with a velocity $\vec{u}$ as shown. A stationary person on the ground observes the stone hitting the object during its downward motion at an angle of 45$^0$ to the horizontal. All the motions are in X–Y plane. Find $\vec{u}$ and the time after which the stone hits the object. Take g = 10 m/s$^2$. **[JEE-2000 (Mains) 5 + 3/100 ]**




**8.** On a frictionless horizontal surface, assumed to be the x – y plane a small trolley A is moving along a straight line parallel to the y – axis as shown in the figure with a constant velocity of ( $\sqrt{3}$ – 1) m/s. At a particular instant, when the line OA makes an angle of 45° with the x – axis, a ball is thrown along the surface from the origin O. Its velocity makes an angle $\phi$ with the x – axis when it hits the trolley.




(a) The motion of the ball is observed from the frame of the trolley. Calculate the angle $\theta$ made by the velocity of the ball with the x – axis in this frame.

(b) Find the speed of the ball with respect to the surface, if $\phi = 4\theta/3$. **[ JEE 2002, 2 + 3/60 ]**

**9.** **STATEMENT -1** **[JEE' 2008, 3/163 ]**

For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary.

**and**

**STATEMENT -2**

If the observer and the object are moving at velocities $\vec{V}_1$ and $\vec{V}_2$ respectively with reference to a laboratory frame, the velocity of the object with respect to the observer is $\vec{V}_2 - \vec{V}_1$.

(A) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 **is** a correct explanation for STATEMENT -1

(B) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 **is NOT** a correct explanation for STATEMENT -1

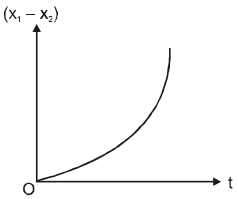
(C) STATEMENT -1 is True, STATEMENT -2 is False

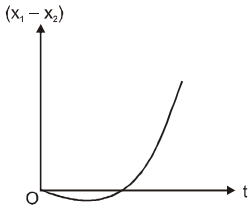
(D) STATEMENT -1 is False, STATEMENT -2 is True.

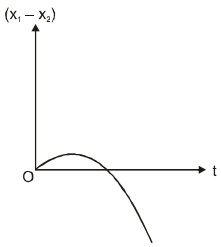
## PART-II AIEEE (PREVIOUS YEARS PROBLEMS)

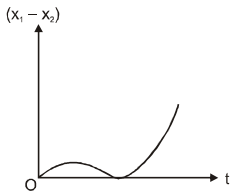
**** Marked Questions are having more than one correct option.***

**1.** A body is at rest at x = 0. At t = 0, it starts moving in the positive x-direction with a constant acceleration. At the same instant another body passes through x = 0 moving in the positive x-direction with a constant speed. The position of the first body is given by $x_1(t)$ after time 't' and that of second body by $x_2(t)$ after the same time interval. Which of the following graphs correctly describes $(x_1 - x_2)$ as a function of time 't' ? **[AIEEE 2008]**

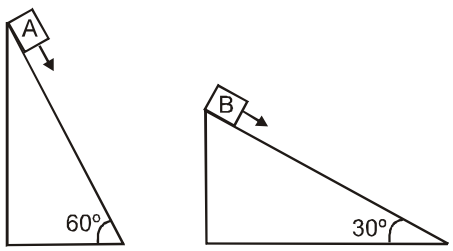
(1) 


(2) 


(3) 


(4) 


**2.** Two fixed frictionless inclined planes making an angle 30° and 60° with the vertical are shown in the figure. Two blocks A and B are placed on the two planes. What is the relative vertical acceleration of A with respect to B? **[AIEEE 2010, 4/144]**




(1) 4.9 $ms^{-2}$ in horizontal direction

(2) 9.8 $ms^{-2}$ in vertical direction

(3) Zero

(4) 4.9 $ms^{-2}$ in vertical direction

# EXERCISE # 4

## NCERT QUESTIONS

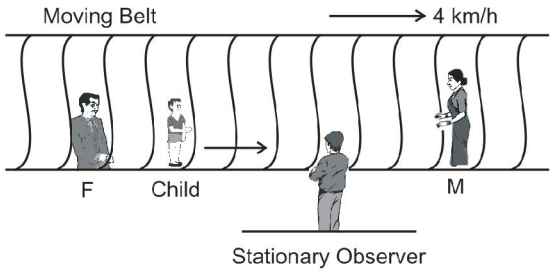
**1.** A jet airplane travelling at the speed of 500 km $h^{-1}$ ejects its products of combustion at the speed of 1500 km $h^{-1}$ relative to the jet plane. What is the speed of the latter with respect to an observer on the ground ?

**2.** Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km $h^{-1}$ in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m $s^{-2}$. If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them ?

**3.** On a two-lane road, car A is travelling with a speed of 36 km $h^{-1}$. Two cars B and C approach car A in opposite directions with a speed of 54 km $h^{-1}$ each. At a certain instant, when the distance AB is equal to AC, both being 1 km, B decides to overtake A before C does. What minimum acceleration of car B is required to avoid an accident ?

**4.** Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km $h^{-1}$ in the direction A to B notices that a bus goes past him every 18 min in the direction of his motion, and every 6 min in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road?

**5.** On a long horizontally moving belt (Fig.), a child runs to and fro with a speed 9 km $h^{-1}$ (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km $h^{-1}$. For an observer on a stationary platform outside, what is the
(a) speed of the child running in the direction of motion of the belt ?.
(b) speed of the child running opposite to the direction of motion of the belt ?
(c) time taken by the child in (a) and (b) ?
Which of the answers alter if motion is viewed by one of the parents ?




**6.** A man can swim with a speed of 4.0 km/h in still water. How long does he take to cross a river 1.0 km wide if the river flows steadily at 3.0 km/h and he makes his strokes normal to the river current? How far down the river does he go when he reaches the other bank ?

**7.** In a harbour, wind is blowing at the speed of 72 km/h and the flag on the mast of a boat anchored in the harbour flutters along the N-E direction. If the boat starts moving at a speed of 51 km/h to the north, what is the direction of the flag on the mast of the boat ?

# ANSWERS

## Exercise # 1

### PART-I

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A-1.** | (C) | **A-2.** | (D) | **A-3.** | (D) | **A-4.** | (D) | **A-5.** | (A) | **A-6.** | (C) | **A-7.** | (B) |
| **A-8.** | (D) | **A-9.** | (C) | **A-10.** | (B) | **A-11.** | (D) | **B-1.** | (B) | **B-2.** | (B) | **B-3.** | (D) |
| **B-4.** | (B) | **B-5.** | (B) | **B-6.** | (C) | **C-1.** | (B) | **C-2.** | (A) | **C-3.** | (C) | **C-4.** | (B) |
| **C-5.** | | **C-6.** | (B) | **D-1.** | (B) | **D-2.** | (B) | **D-3.** | (C) | **D-4.** | (C) | | |

### PART-II

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (B) | **2.** | (B) | **3.** | (C) | **4.** | (D) | **5.** | (A) | **6.** | (B) |

**7.** **(A) – s ; (B) – p ; (C) – r ; (D) – q**

## Exercise # 2

### PART-I

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (B) | **2.** | (A) | **3.** | (C) | **4.** | (A) | **5.** | (B) | **6.** | (A) | **7.** | (AB) |
| **8.** | (ACD) | **9.** | (AD) | **10.** | (AD) | | | | | | | | |

### PART-II

| | | | | | |
|---|---|---|---|---|---|
| **1.** | 5 | **2.** | 5 | **3.** | 3 |

## Exercise # 3

### PART-I

**1.** (A) **2.** (B) **3.** $a > 10\ m/s^2$ **4.** $\frac{25}{\sqrt{8^2-4^2}} = \frac{18}{5}$ minute

**5.** (a) 1s , (b) ( $5\sqrt{3}$ m. 5 m ) **6.** (a) $PQ = (u^2 \sin 2\alpha)/ g \cos\theta$, (b) $V = \frac{u\cos(\alpha+\theta)}{\cos\theta}$ (down the plane)

**7.** $(\frac{15}{4}\hat{i} + \frac{25}{4}\hat{j})$ m/s ; 1 second **8 .** (a) $\theta = 45°$ ; (b) 2 m/s **9.** (B)

### PART-II

| | | | |
|---|---|---|---|
| **1.** | (2) | **2.** | (4) |

## Exercise # 4

**1.** 1000 Km/h **2.** 1250 m **3.** $1\ ms^{-2}$ **4.** T = 9 min., Speed = 400 km/h.

**5.** (a) 13 km $h^{-1}$ ; (b) 5 km $h^{-1}$ ; (c) 20 second in either direction, viewed by any one of the parents, the speed of the child is 9 km $h^{-1}$ in either direction ; answer to c is unaltered.

**6.** 15 min, 750 m **7.** East (approximately)