Exercise-1

Marked Questions can be used as Revision Questions.

PART - I : SUBJECTIVE QUESTIONS

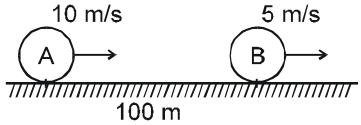
Section : (A) Relative motion in one dimension

A-1. Two parallel rail tracks run north-south. Train A moves due north with a speed of 54 km h^{-1} and train B moves due south with a speed of 90 km h^{-1}. A monkey runs on the roof of train A with a velocity of 18 km/h w.r.t. train A in a direction opposite to that of A. Calculate the
(a) relative velocity of B with respect to A.
(b) relative velocity of ground with respect to B.
(c) velocity of a monkey as observed by a man standing on the ground.
(d) velocity of monkey as observed by a passenger of train B.

A-2. A train is moving with a speed of 40 km/h. As soon as another train going in the opposite direction passes by the window, the passenger of the first train starts his stopwatch and notes that other train passes the window in 3 s. Find the speed of the train going in the opposite direction if its length is 75 m.

A-3. An elevator is descending at a constant speed. A passenger drops a coin on the floor. What will be the acceleration of coin as seen by (a) a person standing on ground and (b) a person at rest with respect to the elevator, shall observe for the falling coin.

A-4. An object A is moving with 10 m/s and B is moving with 5 m/s in the same direction of positive x-axis. A is 100 m behind B as shown. Find the time taken by A to meet B.



A-5. The driver of a train A running at 25 m s^{-1} sights a train B moving in the same direction on the same track with 15 ms^{-1}. The driver of train A applies brakes to produce a deceleration of 1.0 ms^{-2}. What should be the minimum distance between the trains to avoid the accident.

Section : (B) Relative motion in two dimensions

B-1. A particle A moves with a velocity $4\hat{i}$ and another particle B moves with a velocity $-3\hat{j}$. Find $\vec{V}_{AB}$, $\vec{V}_{BA}$ and their magnitude.

B-2. A ship is steaming due east at 12 ms^{-1}. A woman runs across the deck at 5 ms^{-1} (relative to ship) in a direction towards north. Calculate the velocity of the woman relative to sea.

B-3. Two perpendicular rail tracks have two trains A & B respectively. Train A moves towards north with a speed of 54 km h^{-1} and train B moves towards west with a speed of 72 km h^{-1}. Assume that both trains start from same point. Calculate the
(a) Relative velocity of ground with respect to B
(b) Relative velocity of A with respect to B.
(c) Rate of separation of the two trains

B-4. A man is swimming in a lake in a direction of 30° East of North with a speed of 5 km/h and a cyclist is going on a road along the lake shore towards East at a speed of 10 km/h. In what direction and with what speed would the man appear to swim to the cyclist.

B-5. A motorboat is observed to travel 10 km h^{-1} relative to the earth in the direction 37º north of east. If the velocity of the boat due to the wind only is 2 km h^{-1} westward and that due to the current only is 4 km h^{-1} southward, what is the magnitude and direction of the velocity of the boat due to its own power ?

B-6. A ship is sailing towards north at a speed of $\sqrt{2}$ m/s. The current is taking it towards East at the rate of 1 m/s and a sailor is climbing a vertical pole on the ship at the rate of 1 m/s. Find the velocity of the sailor with respect to ground.

Section : (C) Relative motion in river flow & Air flow

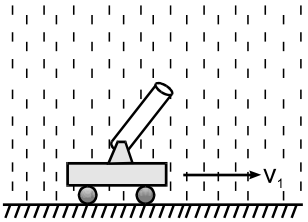
C-1. A swimmer's speed in the direction of flow of river is 16 km h^{-1}. Swimmer's speed against the direction of flow of river is 8 km h^{-1}. Calculate the swimmer's speed in still water and the velocity of flow of the river.

C-2. A man can swim with a speed of 4 km h^{-1} in still water. How long does he take to cross a river 1 km wide if the river flows steadily at 3 km h^{-1} and he makes his strokes normal to the river current ? How far down the river does he go when he reaches the other bank ?

C-3. A river is flowing from west to east at a speed of 5 m/min. A man on the south bank of the river, capable of swimming at 10 m/min in still water, swims across the shortest path distance. In what direction should he swim ?

Section : (D) Relative motion in Rain and wind

D-1. A pipe which can rotate in a vertical plane is mounted on a cart. The cart moves uniformly along a horizontal path with a speed v_1 = 2 m/s. At what angle α to the horizontal should the pipe be placed so that drops of rain falling vertically with a velocity v_2 = 6m/s move parallel to the axis of the pipe without touching its walls ? Consider the velocity of the drops as constant due to the resistance of the air.



D-2. Rain seems to be falling vertically to a person sitting in a bus which is moving uniformly eastwards with 10 m/s. It appears to come from vertical at a velocity 20 m/s. Find the speed of rain drops with respect to ground.

D-3. To a man walking at the rate of 2 km/hour with respect to ground, the rain appears to fall vertically. When he increases his speed to 4 km/hour in same direction of his motion, rain appears to meet him at an angle of 45º with horizontal, find the real direction and speed of the rain.

Section : (E) Velocity of separation & approach

E-1. A particle is kept at rest at origin. Another particle starts from (5m, 0) with a velocity of $-4\hat{i} + 3\hat{j}$ m/s. Find their closest distance of approach.

E-2. Four particles situated at the corners of a square of side 'a', move at a constant speed v. Each particle maintains a direction towards the next particle in succession. Calculate the time the particles will take to meet each other.

E-3. When two bodies move uniformly towards each other, the distance between them diminishes by 16 m every 10 s. If bodies move with velocities of the same magnitude and in the same direction as before the distance between then will decrease 3 m every 5 s. Calculate the velocity of each body.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section : (A) Relative motion in one dimension

A-1. 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. The minimum uniform acceleration of the aeroplane now so that it may escape from being hit ? ($g = 10\ m/s^2$) **[REE-1994, 6]**

(A) $10\ m/s^2$ (B) $8\ m/s^2$ (C) $12\ m/s^2$ (D) None of these

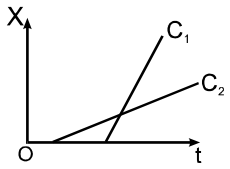
A-2. A stone is thrown upwards from a tower with a velocity $50\ ms^{-1}$. Another stone is simultaneously thrown downwards from the same location with a velocity $50\ ms^{-1}$. When the first stone is at the highest point, the relative velocity of the second stone with respect to the first stone is (assume that second stone has not yet reached the ground) :

(A) Zero (B) $50\ ms^{-1}$ (C) $100\ ms^{-1}$ (D) $150\ ms^{-1}$

A-3. A thief is running away on a straight road with a speed of $9\ m\ s^{-1}$. A police man chases him on a jeep moving at a speed of $10\ m\ s^{-1}$. If the instantaneous separation of the jeep from the motorcycle is 100m, how long will it take for the police man to catch the thief ?

(A) 1s (B) 19s (C) 90s (D) 100s

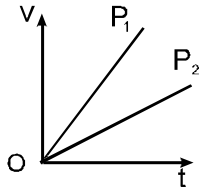
A-4. Shown in the figure are the position time graph for two children going home from the school. Which of the following statements about their relative motion is true after both of them started moving ?



Their relative velocity : (consider 1-D motion)

(A) first increases and then decreases
(B) first decreases and then increases
(C) is zero
(D) is non zero constant.

A-5. 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

A-6. Two trains A and B which are 100 km apart are travelling towards each other on different tracks with each having initial speed of 50 km/h. 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-7. Two cars get closer by 9 m every second while travelling in the opposite direction. They get closer by 1m every second while travelling in the same direction. What are the speeds of the cars?

(A) $5\ ms^{-1}$ and $4\ ms^{-1}$ (B) $4\ ms^{-1}$ and $3\ ms^{-1}$
(C) $6\ ms^{-1}$ and $3\ ms^{-1}$ (D) $6\ ms^{-1}$ and $5\ ms^{-1}$

A-8. A jet airplane travelling from east to west at a speed of $500\ km\ h^{-1}$ eject out gases of combustion at a speed of $1500\ km\ h^{-1}$ with respect to the jet plane. What is the velocity of the gases with respect to an observer on the ground ?

(A) $1000\ km\ h^{-1}$ in the direction west to east (B) $1000\ km\ h^{-1}$ in the direction east to west
(C) $2000\ km\ h^{-1}$ in the direction west to east (D) $2000\ km\ h^{-1}$ in the direction east to west

Section : (B) Relative motion in two dimension

B-1. A helicopter is flying south with a speed of 50 kmh^{-1}. A train is moving with the same speed towards east. The relative velocity of the helicopter as seen by the passengers in the train will be towards.
(A) north east (B) south east (C) north west (D) south west

B-2. 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) π

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

B-4. Two billiard balls are rolling on a flat table. One has velocity components v_x = 1m/s, $v_y = \sqrt{3}$ m/s and the other has components v_x = 2m/s and v_y = 2 m/s. If both the balls start moving from the same point, the angle between their path is -
(A) 60° (B) 45° (C) 22.5° (D) 15°

Section : (C) Relative motion in river flow

C-1. A boat, which has a speed of 5 km/h 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/h is -
(A) 1 (B) 3 (C) 4 (D) $\sqrt{41}$

C-2. To cross the river in shortest distance, a swimmer should swim making angle θ 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) $\cot\theta$

C-3. A boat is rowed across a river (perpendicular to river flow) at the rate of 9 km/hr. The river flows at the rate of 12 km/hr. The velocity of boat in km/hr is:
(A) 14 (B) 15 (C) 16 (D) 17

C-4. A boat which can move with a speed of 5 m/s relative to water crosses a river of width 480 m flowing with a constant speed of 4 m/s. What is the time taken by the boat to cross the river along the shortest path.
(A) 80 s (B) 160 s (C) 240 s (D) 320 s

C-5. An airplane pilot sets a compass course due west and maintains an air speed of 240 km/h. After flying for $\frac{1}{2}$ h, he finds himself over a town that is 150 km west and 40 km south of his starting point. The wind velocity (with respect to ground) is :
(A) 100 km/h, 37° W of S (B) 100 km/h, 37° S of W
(C) 120 km/h, 37° W of S (D) 120 km/h, 37° S of W

Section : (D) Relative motion in Rain and wind

D-1. It is raining vertically downwards with a velocity of 3 km h^{-1}. A man walks in the rain with a velocity of 4 kmh^{-1}. The rain drops will fall on the man with a relative velocity of :
(A) 1 kmh^{-1} (B) 3 kmh^{-1} (C) 4 kmh^{-1} (D) 5 kmh^{-1}

D-2. A man walks in rain with a velocity of 5 kmh^{-1}. The rain drops strike at him at an angle of 45° with the horizontal. The velocity of the rain if it is falling vertically downward is :
(A) 5 kmh^{-1} (B) 4 kmh^{-1} (C) 3 kmh^{-1} (D) 1 kmh^{-1}

D-3. 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

D-4. An aeroplane has 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 υ. The distance between A and B is □. The total time for the round trip is :

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

D-5. A person standing on the escalator takes time t_1 to reach the top of a tower when the escalator is moving. He takes time t_2 to reach the top of the tower when the escalator is standing. How long will he take if he walks up on a moving escalator?

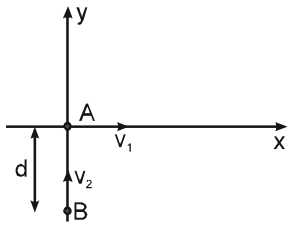
(A) $t_2 - t_1$ (B) $t_1 + t_2$ (C) $t_1 t_2/(t_1 - t_2)$ (D) $t_1 t_2/(t_1 + t_2)$

Section : (E) Velocity of separation & approach

E-1. 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

E-2. 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 figure. 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) $\frac{d.v_2}{\sqrt{v_1^2+v_2^2}}$

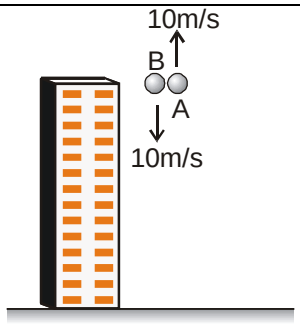
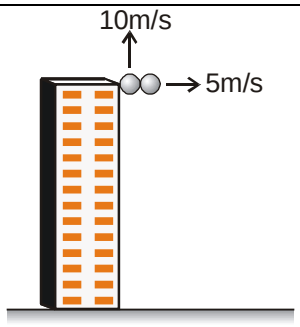
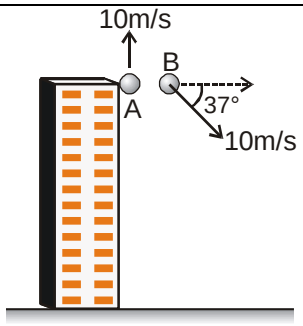
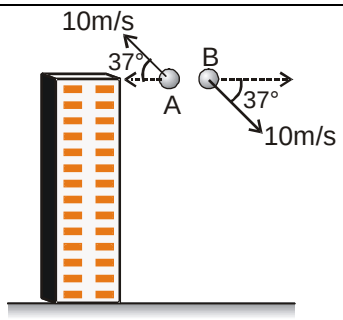
PART - III : MATCH THE COLUMN

1. Match the following :

A ball is thrown vertically upward in the air by a passenger (relative to himself) from a train that is moving as given in column I ($v_{ball} << v_{escape}$). Correctly match the situation as described in the column I, with the paths given in column II.

Column-I	**Column-II**
(A) Train moving with constant acceleration on a slope then path of the ball as seen by the passenger.	(p) Straight line
(B) Train moving with constant acceleration on a slope then path of the ball as seen by a stationary observer outside.	(q) Parabolic
(C) Train moving with constant acceleration on horizontal ground then path of the ball as seen by the passenger.	(r) Elliptical
(D) Train moving with constant acceleration on horizontal ground then path of the ball as seen by a stationary observer outside.	(s) Hyperbolic (t) Circular

2. Both A & B are thrown simultaneously as shown from a very high tower.

	Column-I		**Column-II**
(A)		(p)	Distance between the two balls at two seconds is $16\sqrt{5}$ m.
(B)		(q)	distance between two balls at 2 seconds is 40 m.
(C)		(r)	distance between two balls at 2 sec is $10\sqrt{5}$ m.
(D)		(s)	Magnitude of relative velocity of B w.r.t A is $5\sqrt{2}$ m/s.
		(t)	magnitude of relative velocity of B with respect to A is $5\sqrt{5}$ m/s.

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. Two cars are moving in the same direction with a speed of 30 km h^{-1}. They are separated from each other by 5 km. Third car moving in the opposite direction meets the two cars after an interval of 4 minutes. What is the speed of the third car?
(A) 35 km h^{-1} (B) 40 km h^{-1} (C) 45 km h^{-1} (D) 75 km h^{-1}

2.✍ A bus is moving with a velocity 10 ms^{-1} on a straight road. A scooterist wishes to overtake the bus in 100s. If, the bus is at a distance of 1 km from the scooterist, with what velocity should the scooterist chase the bus? (Neglect size of the bus)
(A) 50 ms^{-1} (B) 40 ms^{-1} (C) 30 ms^{-1} (D) 20 ms^{-1}

3. 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) $\frac{2u+gt}{t}$

4. 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

5.✍ A particle is thrown up inside a stationary lift of sufficient height. The time of flight is T. Now it is thrown again with same initial speed v_0 with respect to lift. At the time of second throw, lift is moving up with speed v_0 and uniform acceleration g upward (the acceleration due to gravity). The new time of flight is–
(A) $\frac{T}{4}$ (B) $\frac{T}{2}$ (C) T (D) 2T

6. A police van moving on a highway with a speed of 30 km h^{-1} fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km h^{-1}. If the muzzle speed of the bullet is 150 ms^{-1}, with what speed does the bullet hit the thief's car (as, seen by thief). According to thief in the car ?
(A) 105 m/s (B) 100 m/s (C) 110 m/s (D) 90 m/s

7. 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

8.✍ A flag on a bus is fluttering in north direction & wind is blowing in east direction. Then which of the following will be true -
(A) bus is moving in south direction.
(B) bus is moving in north east direction.
(C) bus may be moving in any direction between south & east.
(D) bus may be moving in any direction between south & west.

9. For four particles A, B, C & D the velocities of one with respect to other are given as $\vec{V}_{DC}$ is 20 m/s towards north, $\vec{V}_{BC}$ is 20 m/s towards east and $\vec{V}_{BA}$ is 20 m/s towards south. Then $\vec{V}_{DA}$ is
(A) 20 m/s towards north (B) 20 m/s towards south
(C) 20 m/s towards east (D) 20 m/s towards west

10. 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 :

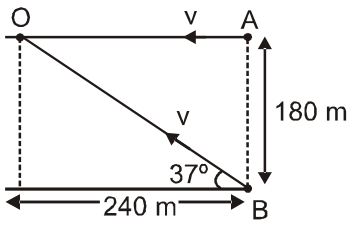
(A) parabola

(B) straight line for sometime & parabola for the remaining time

(C) straight line

(D) variable path that cannot be defined

11. Two persons P and Q start from points A and B respectively as shown in figure. P and Q have speed v = 12 m/s in shown directions towards point O. when the distance between P and Q is 120m, then Q increases its speed to 15 m/s. Then find out who will reach the point O first.



(A) P

(B) Q

(C) both P and Q reaches simultaneously

(D) Data is insufficient

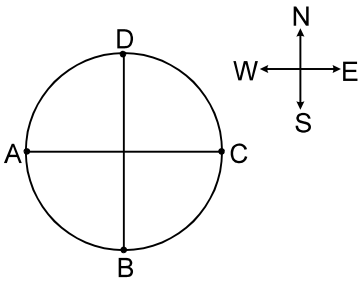
12. A battalion of soldiers is ordered to swim across a river 500 m wide. At what minimum rate should they swim perpendicular to river flow in order to avoid being washed away by the waterfall 300m downstream. The speed of current being 3 m/sec :

(A) 6 m/sec. (B) 5 m/sec. (C) 4 m/sec (D) 2 m/sec

13. 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) $\frac{T^2 + t^2}{T^2 - t^2}$

14. Two aeroplanes fly from their respective positions 'A' and 'B' starting at the same time and reach the point 'C' simultaneously when wind was not blowing. On a windy day they head towards 'C' but both reach the point 'D' simultaneously in the same time which they took to reach 'C'. Then the wind is blowing in



(A) North-East direction

(B) North-West direction

(C) Direction making an angle $0 < \theta < 90$ with North towards East.

(D) North direction

15. A man who is wearing a hat of extended length of 12 cm is running in rain falling vertically downwards with speed 10 m/s. The maximum speed with which man can run, so that rain drops do not fall on his face (the length of his face below the extended part of the hat is 16 cm) will be:

(A) $\frac{15}{2}$ m/s (B) $\frac{40}{3}$ m/s (C) 10 m/s (D) zero

16. A man is standing on a road and observes that rain is falling at angle 45º with the vertical. The man starts running on the road with constant acceleration 0.5 m/s^2. After a certain time from the start of the motion, it appears to him that rain is still falling at angle 45º with the vertical, with speed $2\sqrt{2}$ m/s. Motion of the man is in the same vertical plane in which the rain is falling. Then which of the following statement(s) are true.

(A) It is not possible

(B) Speed of the rain relative to the ground is 2 m/s.

(C) Speed of the man when he finds rain to be falling at angle 45º with the vertical is 4m/s.

(D) Speed of the man when he finds rain to be falling at angle 45º with the vertical is 8m/s.

17. A man is going up in a lift (open at the top) moving with a constant velocity 3 m/s. He throws a ball up at 5 m/sec relative to the lift when the lift is 50 m above the ground. Height of the lift when the ball meets it during its downward journey is (g = 10 m/s^2) **[Olympiad (Stage-1) 2017]**

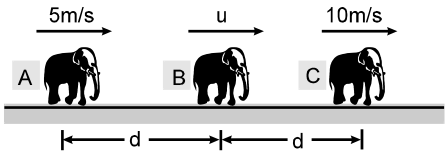
(A) 53 m (B) 58 m (C) 63 m (D) 68 m

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

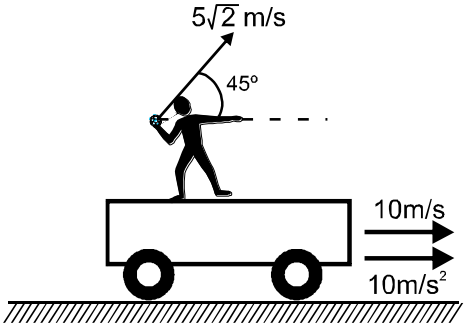
1. Men are running along a road at 15 km/h behind one another at equal intervals of 20 m. Cyclists are riding in the same direction at 25 km/h at equal intervals of 30 m. At what speed (in km/h) an observer travel along the road in opposite direction so that whenever he meets a runner he also meets a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

2. Two identical trains take 3 sec to pass one another when going in the opposite direction but only 2.5 sec if the speed of one is increased by 50 %. Find the time (in sec) one would take to pass the other when going in the same direction at their original speed.

3. 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. Find the speed of B (in m/s).



4. A man standing on a truck which moves with a constant horizontal acceleration a (= 10 m/s^2) when speed of the truck is 10 m/s. The man throws a ball with velocity $5\sqrt{2}$ m/s with respect to truck. In the direction shown in the diagram. Find the distance travelled of ball in meters in one second as observed by the man. (g = 10 m/s^2)



5. Two particles P and Q are moving with constant velocities of $(\hat{i}+\hat{j})$ m/s and $\left(-\hat{i}+2\hat{j}\right)$ m/s respectively. At time t = 0, P is at origin and Q is at a point with position vector $\left(2\hat{i}+\hat{j}\right)$ m. If the equation of the trajectory of Q as observed by P is x + 2y = n, then find n.

6. A boat moves relative to water with a velocity half of the river flow velocity. If the angle from the direction of flow at which the boat must move relative to stream direction to minimize drift is $\frac{2\pi}{n}$, then find n.

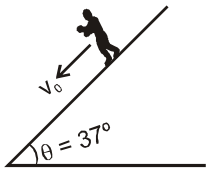
7. A swimmer crosses the river along the line making an angle of 45º with the direction of flow. Velocity of the river water is 5 m/s. Swimmer takes 6 seconds to cross the river of width 60 m. If the velocity of the swimmer with respect to water is $5\sqrt{n}$ m/s, then find n.

8. An aeroplane has to go from a point A to another point B, 1000 km away due 30º west of north. A wind is blowing due north at a speed of 20 m/s. The air-speed of the plane is 150 m/s. If the angle at which the pilot should head the plane to reach the point B is $\sin^{-1}(1/n)$ west of the line AB, Then find n.

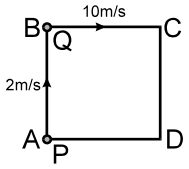
9. Rain appears to be falling at an angle of 37° with vertical to the driver of a car moving with a velocity of 7 m/sec. When he increases the velocity of the car to 25 m/sec, the rain again appears to fall at an angle 37° with vertical. If the actual velocity of rain relative to ground is 4n m/s then find n.

10. During a rainy day, rain is falling vertically with a velocity 2m/s. A boy at rest starts his motion with a constant acceleration of $2m/s^2$ along a straight road. If the rate at which the angle of the axis of umbrella with vertical should be changed is $\frac{1}{n}$ at t = 5s so that the rain falls parallel to the axis of the umbrella, then find n.

11. A man is moving downward on an inclined plane (θ = 37º) with constant velocity v_0 and rain drops appear to him moving in horizontal direction with velocity $2v_0$ towards him. If man increases his velocity to $2v_0$, the velocity of rain drops as observed by man is $\sqrt{\frac{n}{5}}\, v_0$, then find n.

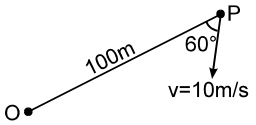


12. Two men P & Q are standing at corners A & B of square ABCD of side 8 m. They start moving along the track with constant speed 2 m/s and 10 m/s respectively. Find the time (in seconds) when they will meet for the first time.



13. Two straight tracks AOB and COD meet each other at right angles at point O. A person walking at a speed of 5 km/h along AOB is at the crossing O at 12 o'clock noon. Another person walking at the same speed along COD reaches the crossing O at 1 : 30 PM. If the time at which the distance between them is least is 12 : T PM, then find T.

14. 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 (in sec) shall P reach O.



PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. A man standing on the edge of the terrace of a high rise building throws a stone vertically up with a speed of 20 m/s. Two seconds later an identical stone is thrown vertically downwards with the same speed of 20 m/s. Then :

(A) the relative velocity between the two stones remain constant till one hits the ground

(B) both will have the same kinetic energy when they hit the ground

(C) the time interval between their hitting the ground is 2 seconds

(D) if the collisions on the ground are perfectly elastic both will rise to the same height above the ground.

2. A man in a lift which is ascending with an upward acceleration 'a' throws a ball vertically upwards with a velocity 'v' with respect to himself and catches it after 't_1' seconds. Afterwards when the lift is descending with the same acceleration 'a' acting downwards the man again throws the ball vertically upwards with the same velocity with respect to him and catches it after 't_2' seconds

(A) the acceleration of the ball with respect to ground is g when it is in air

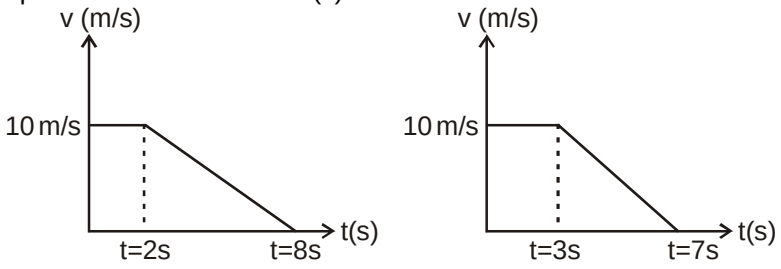
(B) the velocity v of the ball relative to the lift is $\frac{g\,(t_1 + t_2)}{t_1\, t_2}$

(C) the acceleration 'a' of the lift is $\frac{g\,(t_2 - t_1)}{t_1 + t_2}$

(D) the velocity 'v' of the ball relative to the man is $\frac{g\, t_1\, t_2}{(t_1 + t_2)}$

3. A ball is thrown vertically upward (relative to the train) in a compartment of a moving train. (train is moving horizontally)
(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.

4. Car A and car B move on a straight road and their velocity versus time graphs are as shown in figure. Comparing the motion of car A in between t = 0 to t = 8 sec. and motion of car B in between t = 0 to t = 7 sec., pick up the incorrect statement(s).



Car A Car B

(A) Distance travelled by car A is less than distance travelled by car B.
(B) Distance travelled by car A is greater than distance travelled by car B.
(C) Average speed of both cars are equal.
(D) Average speed of car A is less than average speed of car B.

5. At an instant particle-A is at origin and moving with constant velocity $(3\hat{i}+4\hat{j})\ m/s$ and particle-B is at (4, 4)m and moving with constant velocity $(4\hat{i}-3\hat{j})\ m/s$. Then :

(A) at this instant relative velocity of B w.r.t. A is $(\hat{i}-7\hat{j})\ m/s$

(B) at this instant approach velocity of A and B is $3\sqrt{2}$ m/s
(C) relative velocity of B w.r.t. A remains constant
(D) approach velocity of A and B remains constant

6. A person is standing on a truck moving with a constant velocity of 15 m/s on a horizontal road. The man throws a ball in such a way that it returns to his hand after the truck has moved 60 m. ($g = 10\ m/s^2$)
(A) The speed of the ball as seen from the truck is 20 m/s
(B) The direction of initial velocity of ball is upward as seen from the truck
(C) The initial speed of the ball as seen from the ground is 25 m/s
(D) None of these

7. Two boats A and B having same speed relative to river are moving in a river. Boat A moves normal to the river current as observed by an observer moving with velocity of river current. Boat B moves normal to the river as observed by the observer on the ground. Choose the **incorrect** options.
(A) To a ground observer boat B moves faster than A
(B) To a ground observer boat A moves faster than B
(C) To the given moving observer boat B moves faster than A
(D) To the given moving observer boat A moves faster than B

8. An open elevator is ascending with zero acceleration and speed 10 m/s. A ball is thrown vertically up by a boy (boy is in elevator) when he is at a height 10 m from the ground, the velocity of projection is 30m/s with respect to elevator. Choose correct option(s) assuming height of the boy very small : ($g = 10\ m/s^2$)
(A) Maximum height attained by the ball from ground is 90 m.
(B) Maximum height attained by the ball with respect to lift from the point of projection is 45 m.
(C) Time taken by the ball to meet the elevator again is 6 sec
(D) The speed of the ball when it comes back to the boy is 20 m/s with respect to ground.

PART - IV : COMPREHENSION

Comprehension-1

The driver of a car travelling at a speed of 20 m/s, wishes to overtake a truck that is moving with a constant speed of 20 m s^{-1} in the same lane. The car's maximum acceleration is 0.5 m s^{-2}. Initially the vehicles are separated by 40 m, and the car returns back into its lane after it is 40 m ahead of the truck. The car is 3 m long and the truck 17m long.

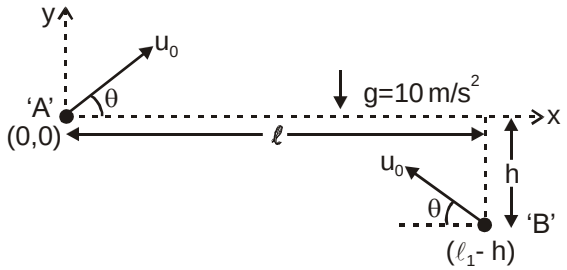
1. Find the minimum time required for the car to pass the truck and return back to its lane?
(A) 10 second (B) 20 second, (C) 15 second (D) none of these.

2. What distance does the car travel during this time?
(A) 500 m (B) 600 m (C) 200 m (D) 300 m

3. What is the final speed of the car ?
(A) 40 m/s (B) 20 m/s (C) 45 m/s (D) 30 m/s

Comprehension-2

Two particles 'A' and 'B' are projected in the vertical plane with same initial speed u_0 from position (0, 0) and (□, – h) towards each other as shown in figure at t = 0.



4. 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.

5. Minimum distance between particle A and B during motion will be :
(A) □ (B) h (C) $\sqrt{\ell^2 + b^2}$ (D) □ + h

6. 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) $\frac{2\ell}{u_0 \cos\theta}$

Comprehension-3

Raindrops are falling with a velocity $10\sqrt{2}$ m/s making an angle of 45^0 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.

7. The magnitude of velocity of man with respect to ground is
(A) $10\sqrt{2}$ m/s (B) 5 m/s (C) 20 m/s (D) 10 m/s

8. After the velocity of rain drops change, the magnitude of velocity of raindrops with respect to ground is
(A) 20 m/s (B) 25 m/s (C) 10 m/s (D) 15 m/s

9. 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

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**
*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

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

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 $\vec{v}_2 - \vec{v}_1$

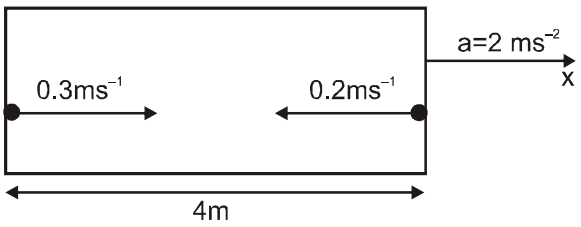
(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 **is** a correct explanation for STATEMENT-1

(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

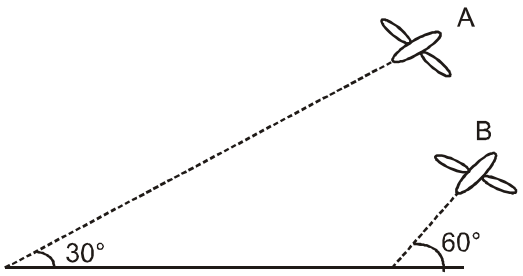
(D) STATEMENT-1 is False, STATEMENT-2 is True.

2. A rocket is moving in a gravity free space with a constant acceleration of $2ms^{-2}$ along +x direction (see figure). The length of a chamber inside the rocket is 4 m. A ball is thrown from the left end of the chamber in +x direction with a speed of $0.3ms^{-1}$ relative to the rocket. At the same time, another ball is thrown in –x direction with a speed of $0.2ms^{-1}$ from its right end relative to the rocket. The time in seconds when the two balls hit each other is **[JEE (Advanced) 2014,P-1, 3/60]**



3. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in figure. The speed of A is $100\sqrt{3}$ ms^{-1}. At time t = 0s, an observer in A finds B at a distance of 500m. This observer sees B moving with a constant velocity perpendicular to the line of motion of A. If at $t = t_0$, A just escapes being hit by B, t_0 in seconds is:

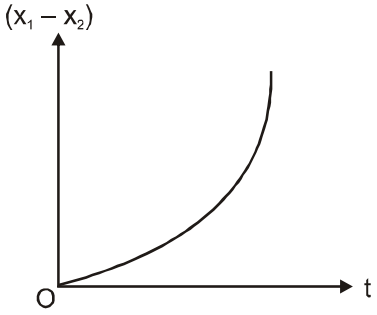
[JEE (Advanced) 2014, P-1, 3/60]



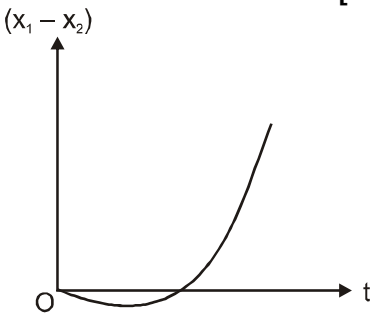
PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

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, 4/120]**

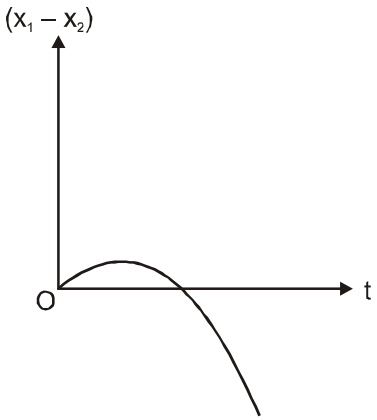
(1)



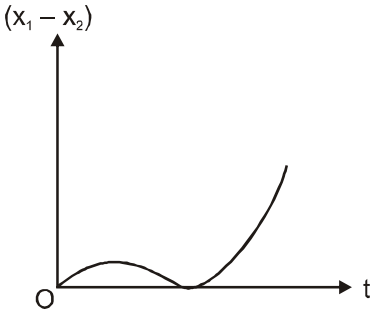
(2)



(3)

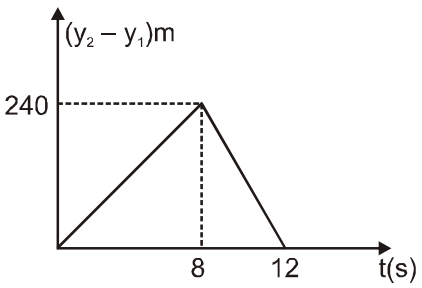


(4)

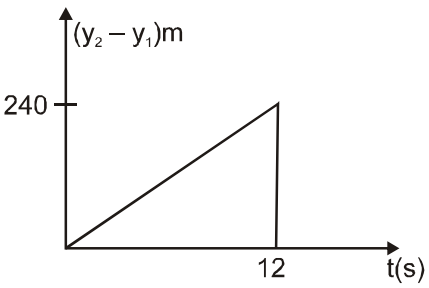


2. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ? (Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/s^2) (The figures are schematic and not drawn to scale.) **[JEE (Main) 2015; 4/120, –1]**

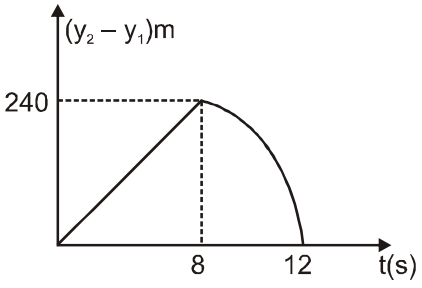
(1)



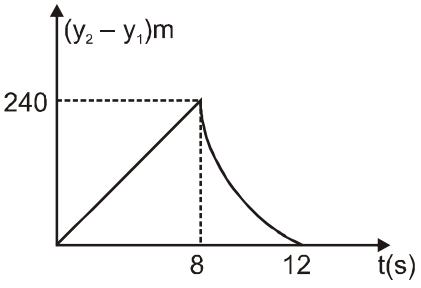
(2)



(3)



(4)



Answers

EXERCISE-1

PART - I

Section (A) :

A-1. (a) 144 km/h due south(b) 90 km/h due north
(c) 36 km/h due north (d) 126 km/h due north

A-2. 50 km/h

A-3. 9.8 m/s^2 downward in both cases.

A-4. 20 sec. **A-5.** 50 m

Section (B) :

B-1. $4\hat{i}+3\hat{j}$, $-4\hat{i}-3\hat{j}$, 5 unit, 5 unit

B-2. 13 m/s, $\tan^{-1}\left(\frac{5}{12}\right)$ = 22°37′ north of east

B-3. (a) 20 m/s or 72 km/h due east
(b) 25 m/s or 90 km/h at 37°N of E
(c) 25 m/s or 90 km/h

B-4. 30ºN of W at $5\sqrt{3}$ km/h

B-5. $10\sqrt{2}$ km/h, 45º N of E

B-6. $\hat{i}+\sqrt{2}\hat{j}+\hat{k}$, $\hat{i}\rightarrow$ east, $\hat{j}\rightarrow$ north,
$\hat{k}\rightarrow$ vertical upward

Section (C) :

C-1. 12 km/h, 4km/h **C-2.** $\frac{1}{4}$ h, $\frac{3}{4}$ km

C-3. At an angle 30° west of north

Section (D) :

D-1. $\alpha = \tan^{-1}3$ **D-2.** $10\sqrt{5}$ m/s

D-3. $2\sqrt{2}$ m/s, 45º with vertical and away from the man.

Section (E) :

E-1. 3 m **E-2.** a/v

E-3. $v_1 = \frac{11}{10}$ m/s and $v_2 = \frac{1}{2}$ m/s.

PART - II

Section (A) :

A-1. (A) **A-2.** (C) **A-3.** (D)
A-4. (D) **A-5.** (D) **A-6.** (D)
A-7. (A) **A-8.** (A)

Section (B) :

B-1. (D) **B-2.** (D) **B-3.** (B)
B-4. (D)

Section (C) :

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

Section (D) :

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

Section (E) :

E-1. (B) **E-2.** (C)

PART - III

1. (A) – q ; (B) – q ; (C) – q ; (D) – q
2. (A) – q ; (B) – r,t ; (C) – p ; (D) – q

EXERCISE-2

PART - I

1.	(C)	**2.**	(D)	**3.**	(B)
4.	(A)	**5.**	(B)	**6.**	(A)
7.	(A)	**8.**	(C)	**9.**	(D)
10.	(C)	**11.**	(A)	**12.**	(B)
13.	(C)	**14.**	(B)	**15.**	(A)
16.	(C)	**17.**	(A)		

PART - II

1.	5	**2.**	15	**3.**	15
4.	0	**5.**	4	**6.**	3
7.	5	**8.**	15	**9.**	5
10.	26	**11.**	41	**12.**	3
13.	45	**14.**	20		

PART - III

1.	(ABCD)	**2.**	(ACD)	**3.**	(ACD)
4.	(ABC)	**5.**	(ABC)	**6.**	(ABC)
7.	(ACD)	**8.**	(ABCD)		

PART - IV

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

EXERCISE-3

PART - I

1. (B) **2.** 2 **3.** 5

PART - II

1. (2) **2.** (3)