Exercise-1

OBJECTIVE QUESTIONS

Marked Questions can be used as Revision Questions.

Section (A) : Relative Motion In One Dimension

A-1. A motorcycle is moving with a velocity 80 km/hr ahead of a car moving with a velocity of 65 km/hr in the same direction. What is the relative velocity of the motorcycle with respect to the car
(1) 15 km/hr (2) 20 km/hr (3) 25 km/hr (4) 145 km/hr

A-2. 50 m long trains are crossing each other in opposite direction with velocity of 10 m/s and 15 m/s. respectively Then time-taken by trains to cross each other will be-
(1) 2 sec. (2) 4 sec. (3) 6 sec. (4) 8 sec.

A-3. Theif's car is moving with a speed of 10 m/s. A police van chasing this car with a speed of 5 m/s fires a bullet at the theif's car with muzzle velocity 72 km/h. Find the speed with which the bullet will hit the car-
(1) 10 m/s (2) 20 m/s (3) 15 m/s (4) 25 m/s

A-4. A person standing on the floor of an elevator drops a coin. The coin reaches the floor of the elevator in a time t_1 if the elevator is stationary and in time t_2 if it is moving with constant velocity. Then-
(1) $t_1 = t_2$ (2) $t_1 < t_2$ (3) $t_1 > t_2$ (4) $t_1 < t_2$ or $t_1 > t_2$

A-5. A train in moving in the north at a speed 10 m/sec. Its length is 150 m. A parrot is flying parallel to the train in the south with a speed of 5m/s. The time taken by the parrot to cross the train will be-
(1) 12 sec. (2) 8 sec. (3) 15 sec. (4) 10 sec.

Section (B) : Relative Motion In Two Dimensions

B-1. A stone is dropped from a running bus. It will travel towards the ground in a-
(1) Straight line (2) Circular path (3) Parabolic path (4) None of these

B-2. A body A is going from South to North and body B is going from West to East with identical Speed. Then direction of relative velocity of A with respect to B is-
(1) North-West (2) South-West (3) North-East (4) South-East

B-3. A stone is just released from the window of a train moving along a horizontal straight track. The stone will hit the ground in-
(1) Straight line path (2) Circular path (3) Parabolic path (4) Hyperbolic path

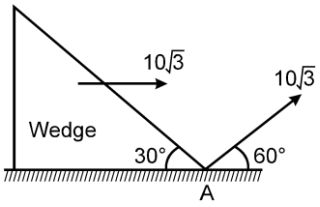
B-4. The motion of one projectile as seen from another will always
(1) Straight line (2) Parabolic (3) Circular (4) Hyperbolic

B-5. The motion of a projectile as seen from other projectile is-
(1) Accelerated motion (2) Uniform motion
(3) Motion with uniform distance (4) None of these

B-6. A traveller while in a uniformly moving train throws a ball up in the air. The ball will return-
(1) In his hand (2) Ahead in the direction of motion of the train
(3) Trail behind (4) Deflected sideways

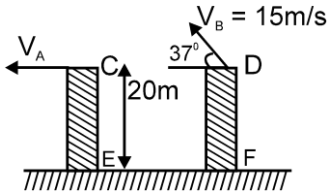
B-7. A body is thrown up in a lift with a velocity U relative to the lift and the time of flight is found to be 't'. The acceleration with which the lift is moving up will be-
(1) $\frac{U-gt}{t}$ (2) $\frac{U+gt}{t}$ (3) $\frac{2U-gt}{t}$ (4) $\frac{2U+gt}{t}$

B-8. A particle is projected at angle 60º with speed $10\sqrt{3}$, from the point 'A' as shown in the fig. At the same time the wedge is made to move with speed $10\sqrt{3}$ towards right as shown in the figure. Then the time after which particle will strike with wedge is ($g = 10\ m/sec^2$) :



(1) 2 sec (2) $2\sqrt{3}$ sec (3) $\frac{4}{\sqrt{3}}$ sec (4) none of these

B-9. CE and DF are two walls of equal height (20 meter) from which two particles A and B of same mass are projected as shown in the figure. A is projected horizontally towards left while B is projected at an angle 37^0 (with horizontal towards left) with velocity 15 m/sec. If A always sees B to be moving perpendicular to EF, then the range of A on ground is :



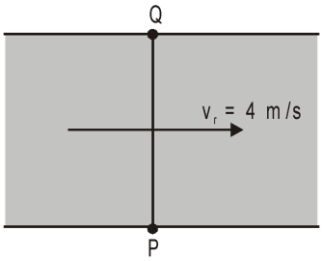
(1) 24 m (2) 30 m
(3) 26 m (4) 28 m

Section (C) : Relative Motion In River Flow & Air Flow

C-1. The speed of a boat is 5 km/hr in still water. If it crosses a river of width 1 km along the shortest possible path in 15 min., then velocity of the river is-
(1) 4 km/hr (2) 3 km/hr (3) 2 km/hr (4) 1 km/hr

C-2. A boat P is moving at 40 km/hr and another boat Q is moving at 20 km/hr. Which one of the following is not a possible value for their relative velocity-
(1) 10 km/hr (2) 20 km/hr (3) 30 km/hr (4) 40 km/hr

C-3. A boat man could row his boat with a speed 10 m/sec. He wants to take his boat from P to a point Q just opposite on the other bank of the river flowing at a speed 4 m/sec. He should row his boat-



(1) At right angle to the stream
(2) At an angle of $\sin^{-1}\left(\frac{2}{5}\right)$ with PQ up the stream
(3) At an angle of $\sin^{-1}\left(\frac{2}{5}\right)$ with PQ down the stream
(4) At an angle of $\cos^{-1}\left(\frac{2}{5}\right)$ with PQ down the stream

C-4. 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, wants to swim across the river in shortest time. He should swim in a direction-
(1) Due north (2) 30° east of north (3) 30° west of north (4) 60° east of north

Section (D) : Relative Motion In Rain And Wind

D-1. A car with a vertical wind shield moves along in a rain strom at speed of 40 km/hr. The rain drops fall vertically with a terminal speed of 20 m/sec. The angle from vertical at which the rain drops strike the wind shield is-

(1) $\tan^{-1}\left(\frac{5}{9}\right)$ (2) $\tan^{-1}\left(\frac{9}{5}\right)$ (3) $\tan^{-1}\left(\frac{3}{2}\right)$ (4) $\tan^{-1}\left(\frac{2}{3}\right)$

D-2. 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 ;
(1) 1 kmh^{-1} (2) 3 kmh^{-1} (3) 4 kmh^{-1} (4) 5 kmh^{-1}

D-3. 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. Velocity of the rain if it is falling vertically downward -
(1) 5 kmh^{-1} (2) 4 kmh^{-1} (3) 3 kmh^{-1} (4) 1 kmh^{-1}

D-4. 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 :
(1) 10 m/s (2) $10\sqrt{3}$ m/s (3) 20 m/s (4) $20\sqrt{3}$ m/s

D-5. 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 υ. The distance between A and B is l. The total time for the round trip is :
(1) $\frac{2\ell}{\sqrt{V^2 - v^2}}$ (2) $\frac{2v\ell}{V^2 - v^2}$ (3) $\frac{2V\ell}{V^2 - v^2}$ (4) $\frac{2\ell}{\sqrt{V^2 + v^2}}$

D-6. A man holding a flag is running in North-East direction with speed 10 m/s. Wind is blowing in east direction with speed $5\sqrt{2}$ m/s. Find the direction in which flag will flutter.
(1) South (2) North (3) East (4) West

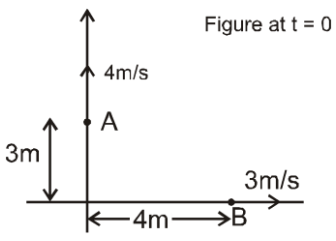
D-7. When a man started from rest with constant acceleration a along an incline plane of angle 37º and he found rain to be falling vertically. After t seconds, he finds rain to strike him horizontally. Assume that actual velocity of rain is constant with magnitude 4 m/s. Choose the correct option :
(1) man is moving up the incline with acceleration of 1 m/s^2 if t = 5 sec.
(2) man is moving down the incline and if a = 1 m/s^2 then t = 5 sec.
(3) man is moving down the incline and if t = $\frac{20}{3}$ s then a = 1 m/s^2
(4) man is moving up the incline and if a = 1 m/s^2 then t = $\frac{20}{3}$ s.

Section (E) : Velocity Of Separation & Approach

E-1. A car is moving towards south with a speed of 20 m/s. A motorcylist is moving towards east with a speed of 15 m/s. At a certain instant (t = 0) the motorcyclist is due south of the car and is at a distance of 50m from the car. The shortest distance between the motorcyclist and the car is and the time after which they are nearest to each other after t = 0 :
(1) 10 m, 1.6 sec. (2) 20 m, 1 sec. (3) 30 m, 1.6 sec. (4) 40 m, 1 sec.

E-2. Two particles A and B are initially 40 m apart. A is behind B. Particle A is moving with uniform velocity of 10m/s towards B. Particle B starts from rest moving away from A with constant acceleration of 2 m/s^2. The minimum distance between the two is :
(1) 15 m (2) 20 m (3) 25 m (4) 30 m

E-3. Particles A and B are moving with constant velocity in two perpendicular directions as shown in diagram at t = 0. Find the velocity of separation at t = 0 and t = 1 second respectively.



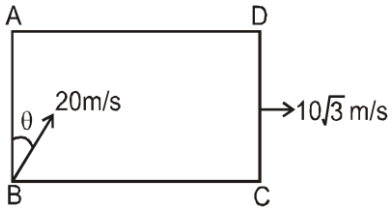
(1) 5 m/s, $\frac{7}{\sqrt{3}}$ m/s (2) 4.8 m/s , $\frac{7}{\sqrt{3}}$ m/s
(3) 4.8m/s, $\frac{7}{\sqrt{2}}$ (4) 4.8 m/s, $\frac{7}{\sqrt{3}}$ m/s

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

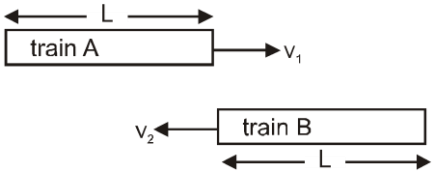
1. In given figure, a smooth square platform ABCD is moving towards right with a uniform speed $10\sqrt{3}$ m/s. At what angle θ must a particle be projected from B with speed 20 m/s w.r.t. ground so that it strikes the point A?



(1) 60º (2) $\cos^{-1}\left(\frac{2}{\sqrt{3}}\right)$

(3) 30º (4) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$

2. Two identical trains take 3 sec. to pass one another when going in opposite direction. But takes only 2.5 sec, if the speed of one is increased by 50%. The time one would take to pass the other when going in the same direction at their original speed is- (both train is moving with constant velocity)



(1) 10 sec. (2) 12 sec. (3) 15 sec. (4) 18 sec.

3. Two cars are moving in the same direction with the same speed 30 km/hr. They are separated by a distance of 5 km, the speed of a car moving in the opposite direction if it meets these two cars at an interval of 4 minutes, will be-

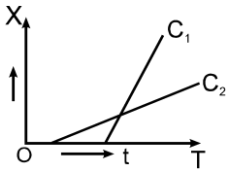
(1) 40 km/hr (2) 45 km/hr (3) 30 km/hr (4) 15 km/hr

4. A thief is running away on a straight road in a jeep moving with a speed of 9 m s^{-1}. A police man chases him on a motor cycle 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?

(1) 1s (2) 19s (3) 90s (4) 100s

5. 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)

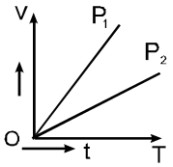


(1) first increases and then decreases (2) first decreases and then increases

(3) is zero (4) is non zero constant.

6. 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?

Their relative speed : (consider 1-D motion)



(1) is zero (2) is non-zero but constant

(3) continuously decreases (4) continuously increases

7. 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 w.r.t. the first stone is (assume that second stone has not yet reachead the ground) :

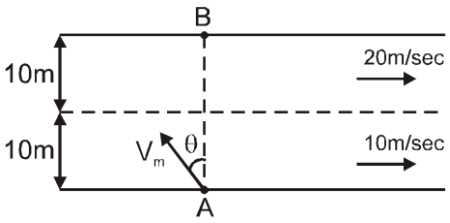
(1) Zero (2) 50 ms^{-1} (3) 100 ms^{-1} (4) 150 ms^{-1}

8. Two particles are moving with velocities v_1 and v_2. Their relative velocity is the maximum, when the angle between their velocities is :

(1) zero (2) π/4 (3) π/2 (4) π

9. A ball is thrown from rear end of the compartment to the front end which is moving at constant horizontal velocity. An observer A sitting in the compartment and another observer B standing on the ground draw the trajectory. They will have-
(1) Equal horizontal and equal vertical ranges.
(2) Equal vertical ranges but different horizontal ranges.
(3) Different vertical ranges but equal horizontal ranges.
(4) Different vertical and different horizontal ranges.

10. In a river of 20 m width. Half part of river flows with speed 10 m/sec and remaining half part flows with 20 m/sec. as shown in figure. A man starts to swim from A and reaches to point B in 10 sec. Man swims with speed V_m with respect to river at an angle θ with line AB. Then, angle θ will be : (man swims with constant speed and in same direction with respect to river throughout the motion) :

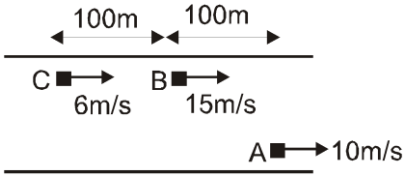


(1) $\tan^{-1}(5)$ (2) $\tan^{-1}\left(\frac{15}{2}\right)$ (3) $\cos^{-1}\left(\frac{2}{15}\right)$ (4) $\tan^{-1}\left(\frac{1}{5}\right)$

11. 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]
(1) $\cos\theta$ (2) $\sin\theta$ (3) $\tan\theta$ (4) $\cot\theta$

12. A man standing on a road hold his umbrella at 30º with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/hr. He finds that raindrops are hitting his head vertically, the speed of raindrops with respect to the road will be
(1) 10 km/hr (2) 20 km/hr (3) 30 km/hr (4) 40 km/hr

13. Three cars A,B,C are moving on a straight highway with constant velocity 10 m/s, 15 m/s and 6 m/s. Figure shows their separation at an instant. What will be the separation between B and C at the moment when B overtakes A :



(1) 180 m (2) 280 m
(3) 140 m (4) 320 m

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/Reasoning

A-1. **STATEMENT-1 :** Three projectiles are moving in different paths in the air. Vertical component of relative velocity between any of the pair does not change with time as long as they are in air. Neglect the effect of air friction.
STATEMENT-2 : Relative acceleration between any of the pair of projectiles is zero.
(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

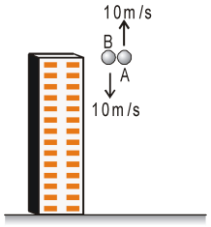
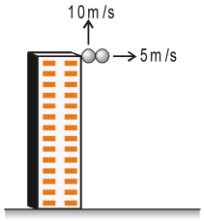
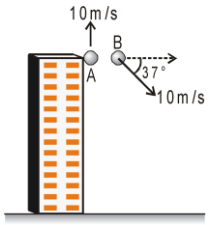
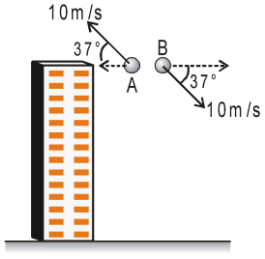
A-2. **STATEMENT-1 :** If seperation between two particles does not change then their relative velocity will be zero.
STATEMENT-2 : Relative velocity is the rate of change of position of one particle w.r.t. another.
(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

A-3. **STATEMENT-1 :** If speed of two particles is increasing at the same rate then their relative velocity will be constant.
STATEMENT-2 : If the acceleration vector of the two particles is same then their relative acceleration will be zero.
(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

A-4. **STATEMENT-1 :** Path of a projectile, seen from another projectile is straight line.
STATEMENT-2 : If relative acceleration is zero then relative velocity will be constant.
(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

Section (B) : Match the following

B-1. **Match the following :**
Both A & B are thrown simultaneously as shown from a very high tower.

Column I	Column II
(1) 	(p) Distance between the two balls after two seconds is $16\sqrt{5}$ m.
(2) 	(q) Distance between two balls after 2 seconds is 40 m.
(3) 	(r) Magnitude of relative velocity of B with respect to A is $5\sqrt{5}$ m/s.
(4) 	(s) Magnitude of relative velocity of B w.r.t A is $5\sqrt{2}$ m/s.

Section (C) : One or More Than One Options Correct

C-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 :
(1) The relative velocity between the two stones remain constant till one hits the ground
(2) Both will have the same kinetic energy when they hit the ground
(3) The time interval between their hitting the ground is 2 seconds
(4) If the collisions on the ground are perfectly elastic both will rise to the same height above the ground.

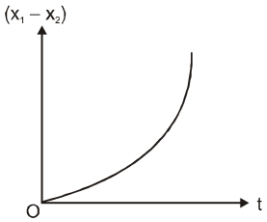
C-2. A ball is thrown vertically upward (relative to the train) in a compartment of a moving train. (train is moving horizontally)
(1) The ball will maintain the same horizontal velocity as that of the person (or the compartment) at the time of throwing.
(2) If the train is accelerating then the horizontal velocity of the ball will be different from that of the train velocity, at the time of throwing.
(3) If the ball appears to be moving backward to the person sitting in the compartment it means that speed of the train is increasing.
(4) If the ball appears to be moving ahead of the person sitting in the compartment it means the train's motion is retarding.

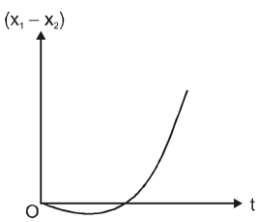
C-3. A man in a lift which is ascending with an upward acceleration 'a' throws a ball vertically upwards with a velocity 'v' with respect to himself and catches it after 't_1' seconds. Afterwards when the lift is descending with the same acceleration 'a' acting downwards the man again throws the ball vertically upwards with the same velocity with respect to him and catches it after 't_2' seconds
(1) The acceleration of the ball with respect to ground is g when it is in air
(2) The velocity v of the ball relative to the lift is $\frac{g(t_1+t_2)}{t_1\ t_2}$
(3) The acceleration 'a' of the lift is $\frac{g\,(t_2-t_1)}{t_1+t_2}$
(4) The velocity 'v' of the ball relative to the man is $\frac{g\ t_1\ t_2}{(t_1+t_2)}$

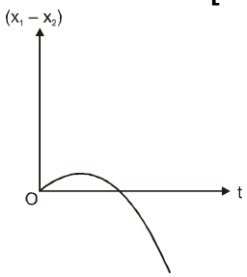
Exercise-3

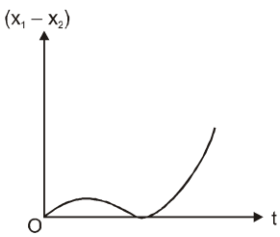
PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

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 thesame time interval. Which of the following graphs correctly describes $(x_1 - x_2)$ as a function of time 't' ? **[AIEEE 2008]**

(1) 

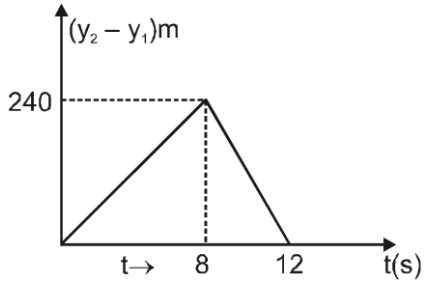
(2) 

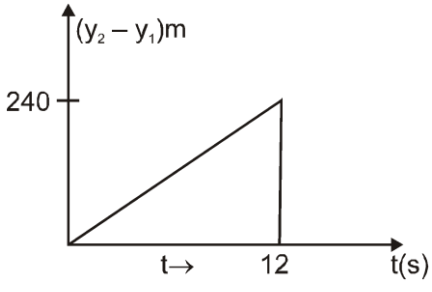
(3) 

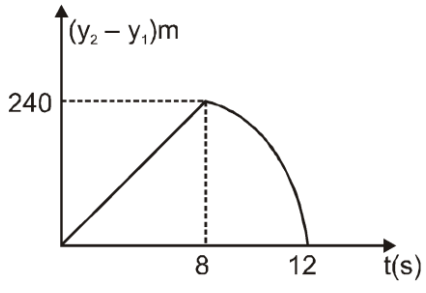
(4) 

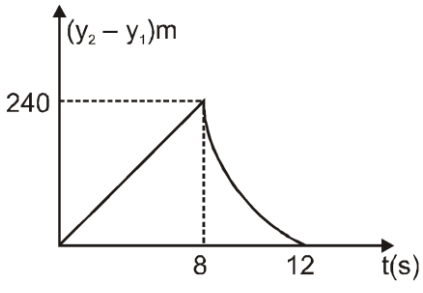
2. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ? **[JEE(Main)-2015; 4/120, –1]**
(assume 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.)

(1)


(2)


(3)


(4)


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

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]**

(1) due north (2) 30^0 east of north

(3) 30^0 west of north (4) 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]**

(1) 1 (2) 3 (3) 4 (4) $\sqrt{41}$

3. **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 $\vec{v}_2 - \vec{v}_1$.

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

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

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

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

Answers

EXERCISE # 1

Section (A)

A-1. (1) **A-2.** (2) **A-3.** (3)

A-4. (1) **A-5.** (4)

Section (B)

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

B-4. (1) **B-5.** (2) **B-6.** (1)

B-7. (3) **B-8.** (1) **B-9.** (1)

Section (C)

C-1. (2) **C-2.** (1) **C-3.** (2)

C-4. (1)

Section (D)

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

D-4. (2) **D-5.** (1) **D-6.** (1)

D-7. (3)

Section (E)

E-1. (3) **E-2.** (1) **E-3.** (3)

EXERCISE # 2

PART-I

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

4. (4) **5.** (4) **6.** (4)

7. (3) **8.** (4) **9.** (2)

10. (2) **11.** (2) **12.** (2)

13. (2)

PART-II

Section (A)

A-1. (1) **A-2.** (4) **A-3.** (4)

A-4. (1)

Section (B)

B-1. (1 → q), (2 → r), (3 → p), (4 → q)

Section (C)

C-1. (1,2,3,4) **C-2.** (1,3,4)

C-3. (1,3,4)

EXERCISE # 3

PART-I

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

PART-II

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