EXERCISE-1

OBJECTIVE PROBLEMS

1. A stone is thrown upwards 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 :

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

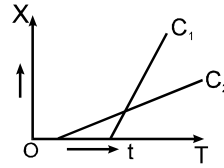
2. A thief is running away on a straight road in a jeep moving with a speed of 9 m s^{-1}. A police man chases him on a motor cycle moving at a speed of 10 m s^{-1}. If the instantaneous separation of the jeep from the motorcycle is 100m, how long will it take for the police man to catch the thief?

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

3. 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) 30 km h^{-1} (B) 35 km h^{-1} (C) 40 km h^{-1} (D) 45 km h^{-1}

4. Shown in the figure are the displacement time graph for two children going home from the school. Which of the following statements about their relative motion is true?



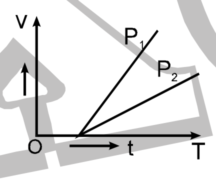
Their relative velocity :

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

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 a moving escalator?

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

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 velocity :

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

7. Two particles P_1 and P_2 are moving with velocities v_1 and v_2 respectively. Which of the statement about their relative velocity $v_{r\,12}$ is true?

(A) $v_{r\,12} > (v_1 + v_2)$ (B) $v_{r\,12}$ cannot be greater than $v_1 - v_2$
(C) $v_{r\,12}$ cannot be greater than $v_1 + v_2$ (D) $v_{r\,12} < (v_1 + v_2)$

8. 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 %. The time one would take to pass the other when going in the same direction at their original speed is :

(A) 10 sec (B) 12 sec (C) 15 sec (D) 18 sec

9. 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°

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

(A) 6 m.p.h. (B*) 5 m.p.h. (C) 4 m.p.h. (D) 2 m.p.h.

11. 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 -

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

12. A bucket is placed in the open where the rain is falling vertically. If a wind begins to blow 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

13. A car with a vertical wind shield moves along in a rain storm at the speed of 40 km/hr. The rain drops fall vertically with a terminal speed of 20 m/s. The angle with the vertical at which the rain drop strike the wind shield is -
(A) $\tan^{-1}(5/9)$ (B) $\tan^{-1}(9/5)$ (C) $\tan^{-1}(3/2)$ (D) $\tan^{-1}(3)$

SUBJECTIVE PROBLEMS

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

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

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

17. A motor boat has 2 throttle position on its engine. The high speed position propels the boat at 10 km hr^{-1} in still water and the low position gives half the higher speed. The boat travels from its dock downstream on a river with the throttle at low position and returns to its dock with throttle at high position. The return trip took 15 % longer time than it did for the downstream trip. Find the velocity of the water current in the river.

18. (I) 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 ?
(II) If he keeps himself always at an angle of 120°C with the river flow while swimming.
(a) Find the time he takes to cross the river. (b) At what point on the opposite bank will he arrive ?

19. 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 distance. In what direction should he swim ?

20. An airplane is flying with velocity $50\sqrt{2}$ km/hour in north-east direction. Wind is blowing at 25 km/hr from north to south. What is the resultant displacement of airplane in 2 hours ?

21. When a train has a speed of 10 m s^{-1} eastward, raindrops that are falling vertically with respect to the earth make traces that are inclined 30º to the vertical on the windows of the train.
(a) What is the horizontal component of a drop's velocity with respect to the earth ? With respect to the train ?
(b) What is the velocity of the raindrop with respect to the earth ? With respect to the train ?

22. To a man walking at 7 km/h due west, the wind appears to blow from the north-west, but when he walks at 3 km/h due west, the wind appears to blow from the north. What is the actual direction of the wind and what is its velocity ?

23. When a motorist is driving with velocity $6\hat{i} + 8\hat{j}$, the wind appears to come from the direction $\hat{i}$. When he doubles his velocity the wind appears to come from the direction $\hat{i} + \hat{j}$. Then the true velocity of the wind expressed in the form of $a\hat{i} + b\hat{j}$ is ______.

24. 'n' numbers of particles are located at the vertices of a regular polygon of 'n' sides having the edge length 'a'. They all start moving simultaneously with equal constant speed 'v' heading towards each other all the time. How long will the particles take to collide?

25. Two ships are 10 km apart on a line running south to north. The one further north is streaming west at 40 km/hr. The other is streaming north at 40 km/hr. What is their distance of closest approach and how long do they take to reach it?

26. 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 in space.

27. A motorboat is observed to travel 10 km hr^{-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 hr^{-1} westward and that due to the current only is 4 km hr^{-1} southward, what is the magnitude and direction of the velocity of the boat due to its own power ?

28. A person P sitting on a wooden block (which does not move relative to water) in a flowing river sees two swimmers A and B. A and B both have constant speed v_m relative to water. P observes that A starts from one point of the river bank and appears to move perpendicular to the river flow. P also observes that B starts from some point on the other bank at the same time and moves downstream. The width of the river is ' d ' and it flows with velocity v_r. If A and B both reach a point at the same time, than find the initial separation between A and B.

29. A motorboat going down stream overcome a float at a point M. 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.

30. 2 swimmers start from point A on one bank of a river to reach point B on the other bank, lying directly opposite to point A. One of them crosses the river along the straight line AB, while the other swims at right angles to the stream and then walks the distance which he has been carried away by the stream to get to point B. What was the velocity (assumed uniform) of his walking if both the swimmers reached point B simultaneously. Velocity of each swimmer in still water is 2.5 km hr^{-1} and the stream velocity is 2 km hr^{-1}.

31. An airplane pilot sets a compass course due west and maintains an air speed of 240 km. hr^{-1}. After flying for $\frac{1}{2}$ hr, he finds himself over a town that is 150 km west and 40 km south of his starting point.

(a) Find the wind velocity, in magnitude and direction.

(b) If the wind velocity were 120 km. hr^{-1} due south, in what direction should the pilot set his course in order to travel due west ? Take the same air speed of 240 km. hr^{-1}.

32. Two straight AOB and COD meet each other right angles. A person walking at a speed of 5 km/hr along AOB is at the crossing O at noon. Another person walking at the same speed along COD reaches the crossing O at 1:30 PM. Find at what time the distance between them is least and what is its value?

EXERCISE-2

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. What should be the acceleration of the aeroplane so that it may escape from being hit? **[REE '94, 6]**

2. 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.

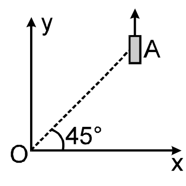
[REE '95, 6]

3. 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 45º with the x – axis, a ball is thrown along the surface from the origin O. Its velocity makes an angle ϕ 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 θ 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]



ANSWER

EXERCISE # 1

OBJECTIVE PROBLEMS

1. C **2.** D **3.** D **4.** D
5. **D** **6.** D **7.** C **8.** C
9. D **10.** **B** **11.** B **12.** **A**
13. A

SUBJECTIVE PROBLEMS

14. 5 km/h

15. (a) 25 m/s or 90 km/hr (b) 20 m/s or 72 km/hr due east (c) 25 m/s or 90 km/hr at 37°N of E

16. 30º N of W at $5\sqrt{3}$ km/hr. **17.** 3 km/hr.

18. (I) **0.75 km**

(II) **(a)** $\frac{1}{2\sqrt{3}}$ **h** **(b)** $\frac{1}{2\sqrt{3}}$ **km.**

19. At an angle 30° west of north.

20. $50\sqrt{5}$ km

21. (a) 0, 10 m/s West (b) $10\sqrt{3}$ m/s, 20 m/s

22. Coming from 5 km/hr, 53° N of E

23. $\left(4\hat{i} + 8\hat{j}\right)$ *24.* $\frac{a}{v\left(1-\cos\frac{2\pi}{n}\right)}$

25. $\frac{10}{\sqrt{2}}, \frac{1}{8}$ hr

26. 2m/s in a direction making an angle of 60º with E, 45º with N and 60º with the vertical

27. $10\sqrt{2}$ km/hr, 45º N of E

28. $\sqrt{2}\,d$ **29.** 3 km/hr

30. 3 km/hr towards B

31. (a) 100 km/hr, 37° W of S (b) 30° N of W

32. 12 : 45 PM

EXERCISE # 2

1. a > 10 m/s^2 **2.** 3.6 minute

3. (a) $\theta = 45º$; (b) 2 m/s

