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Exercise

Kinematics- 2D

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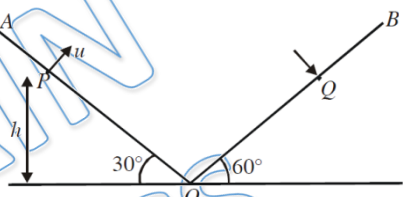
Exercise-4

(Subjective Type: Level- 2)

Q 1. A particle is projected from O at an elevation α and after t second it has an elevation β as seen from the point of projection. Prove that its initial velocity is $\frac{gt\cos\beta}{\sin(\alpha-\beta)}$.

Q 2. A man can throw a stone with initial speed of 10 m/s. Find the maximum horizontal distance to which he can throw the stone in a room of height h for : (i) h = 2 m & (ii) h = 4 m

Q 3. Two inclined planes OA and OB having inclinations 30° and 60° respectively intersect each other at O as shown in figure. A particle is projected from point P with velocity u = 10 $\sqrt{3}$ m/s along a direction perpendicular to plane OA. If the particle strikes the plane OB perpendicularly at Q. Calculate



(i) Time of flight.

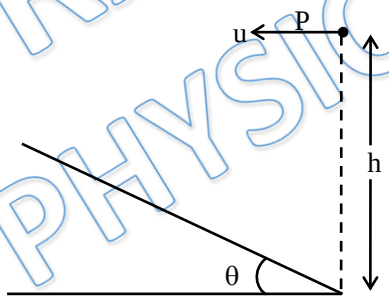
(ii) Velocity with which particle strikes the plane OB.

(iii) Vertical height of P from O.

(iv) Maximum height from O attained by the particle.

(v) Distance PQ.

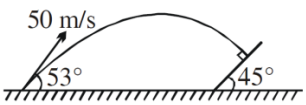
Q 4. Determine the velocity with which a stone must be projected horizontally from a point P, so that it may hit the inclined plane perpendicularly. The inclination of the plane with the horizontal is θ and P is h metre above the foot of the incline as shown in the figure.



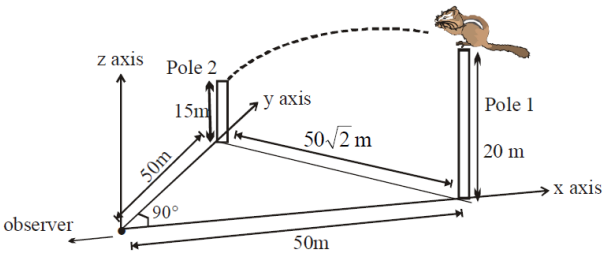
Q 5. A projectile is thrown with velocity of 50 m/s towards an inclined plane from ground such that it strikes the inclined plane perpendicularly. The angle of projection of the projectile is 53° with the horizontal and the inclined plane is inclined at an angle of 45° to the horizontal.

(i) Find the time of flight.

(ii) Find the distance between the point of projection and the foot of inclined plane.



Q 6. A small squirrel jumps from pole 1 to pole 2 in horizontal direction. Squirrels is observed by a very small observer at origin. What is average velocity vector of squirrel ? If average velocity vector is expressed as $v_x\hat{i}+v_y\hat{j}+v_z\hat{k}$ express your answer as sum of magnitudes of its components $|v_x|+|v_y|+|v_z|$ in unit m/s.



Q 7. Two particles start simultaneously from a point and move along line OP and OQ, one with a uniform velocity 10 m/s and other from rest with a constant acceleration 5 m/s^2 respectively. Line OP makes an angle 37º with the line OQ. Find the time at which they appear to each other moving at minimum speed?

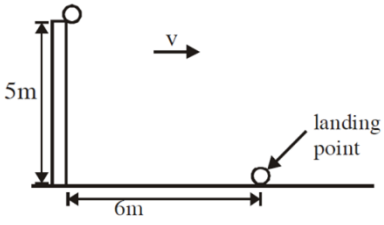
Q 8. A particle is projected with a velocity $2\sqrt{ag}$ so that it just clears two walls of equal height 'a', which are at a distance $2a$ apart. Find time of passing between the walls ?

Q 9. Two guns, situated at the top of a hill of height 10 m, fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time. One gun fires horizontally and other fires at an angle of 60° up the horizontal. The shots collide in air at a point P. Find

(i) the time interval between the firings, and (ii) the coordinates of the point P.

(Take origin of the coordinates system at the foot of the hill vertically below the muzzle and trajectories in X-Y plane)

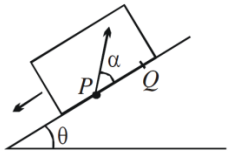
Q 10. A ball is dropped from rest from a tower of height 5m. As a result of the wind it lands at a distance 6m from the bottom of the tower as shown. Assuming no air resistance but that the wind gives the ball a constant horizontal velocity v. Find value of v in m/s.



Q 11. A hunter is riding an elephant of height 4 m moving in straight line with uniform velocity of 2 m/s. A deer starts running with uniform velocity from a point $4\sqrt{5}$ m away in front of the

elephant along a line perpendicular to velocity of the elephant. If hunter can throw his spear with a speed of 10 m/s, relative to the elephant, at what angle θ to it's direction of motion must he throw his spear horizontally for a successful hit. Find also the speed of the deer.

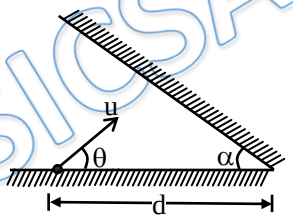
Q 12. A large heavy box is sliding without friction down a smooth plane of inclination q. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to box is u and the direction of projection makes an angle a with the bottom as shown in figure.



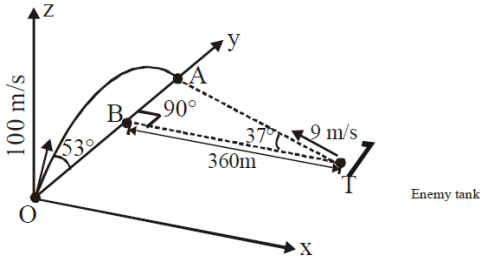
(i) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands. (Assume that the particle does not hit any other surface of the box. Neglect air resistance).

(ii) 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.

Q 13. A projectile is fired with velocity u at an angle θ so as to strike a point on the inclined plane inclined at an angle α with the horizontal. The point of projection is at a distance d from the inclined plane on the ground as shown in the figure. The angle θ is adjusted in such a way that the projecile can strike the inclined plane in minimum time, find that minimum time.

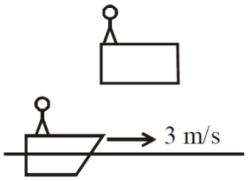


Q 14. A tank is initially at a perpendicular distance BT = 360 m from the plane of firing as shown. The enemy tank is moving with a speed of 9 m/s in direction TA as shown in figure. A gun can fire shell in y-z plane only with a speed 100 m/s at an angle of 53° such that the shell lands at points A. If tank started at t = 0 then time interval (in sec) after which shell is to be fired to hit the tank is



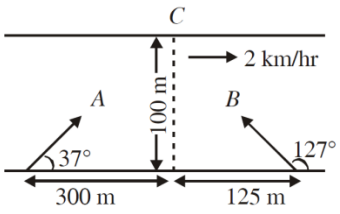
Q 15. A particle is projected from ground towards a vertical wall 80 m away at an angle of 37° with horizontal with initial velocity of 50 m/s. After its collision with wall & then once with ground find at what distance in meter from wall will it strike the ground. The component of velocity normal to the surface becomes half after collision with each surface.

Q 16. You are standing on the chambal Bridge watching the boats in the river. You see a motorboat pass directly below you, traveling perpendicular to the bridge at a speed of 3 m/s. A person on the boat throws a baseball at an initial speed of v_0 and at an angle of 37° from the vertical (Note: both v_0 and the angle are with respect to the boat). Find the value of v_0 (in m/s) necessary for the ball to travel straight up towards you.



Q 17. Two bodies are thrown simultaneously from the same point. One thrown straight up and the other at an angle α with the horizontal. Both the bodies have equal velocity of v_0. Neglecting air drag, find the separation of the particle at time t.

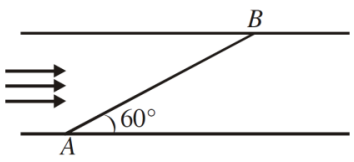
Q 18. Two swimmers start a race. One who reaches the point C first on the other bank wins the race. Boy A makes his strokes in a direction of 37° to the river flow with velocity 5 km/hr relative to water. Boy B makes his strokes in a direction of 127° to the river flow with same relative velocity. River is flowing with speed of 2 km/hr and is 100 m wide. Who will win the race? Compute the time taken by A and B to reach the point C if the speeds of A and B on the ground are 8 km/hr and 6 km/hr respectively.



Q 19. A swimmer starts to swim from point A to cross a river. He wants to reach point B on the opposite side of the river. The line AB makes an angle 60° with the river flow as shown. The velocity of the swimmer in still water is same as that of the water

(i) In what direction should he try to direct his velocity? Calculate angle between his velocity and river velocity.

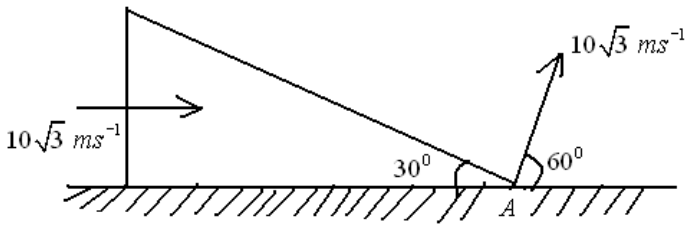
(ii) Find the ratio of the time taken to cross the river in this situation to the minimum time in which he can cross this river.



Q 20. Hailstones falling vertically with speed of 10 m/s hit with respect to himself the windscreen of a moving car and rebound elastically. Find the velocity of the car if the driver find the hailstones rebound vertically after striking. Windscreen makes an angle 30° with the horizontal.

Q 21. An aeroplane flies horizontally at height *h* at a constant speed *v*. An anti-aircraft gun fires a shell at the plane when it is vertically above the gun. Find minimum muzzle velocity and corresponding angle of projection of the shell required to hit the plane?

Q 22. A particle is projected at an angle 60^0 with a speed of $10\sqrt{3}ms^{-1}$ from point A as shown. At the same time the wedge is made to move with constant velocity of $10\sqrt{3}$ towards right as shown in figure. Find the time in second after which particle will hit the wedge.
$\left(g = 10ms^{-2}\right)$



Answer Key

Ans. 2 (i) $4\sqrt{6}$ m, (ii) 10 m

Ans. 3 (i) 2 s (ii) 10 m/s (iii) 5m (iv) 16.25 m (v) 20 m

Ans. 4 $\sqrt{\frac{2gh}{2+cot^2\theta}}$

Ans. 5 (i) 7 s, (ii) 175 m

Ans. 6 0105

Ans. 7 t = 1.6 s

Ans. 8 $2\sqrt{a/g}$.

Ans. 9 (i) 1 s, (ii) ($5\sqrt{3}$ m, 5 m)

Ans. 10 6

Ans. 11 θ = 37°, v = 6 m/s

Ans. 12 (i) $\frac{u^2 \sin 2\alpha}{g\cos\theta}$ (ii) $v = \frac{u\cos(\alpha+\theta)}{\cos\theta}$

Ans. 13 t = $\frac{u-\sqrt{u^2-gd\sin 2\alpha}}{g\cos\alpha}$

Ans. 14 34

Ans. 15 140

Ans. 16 5

Ans. 17 $v_0 t\ \sqrt{2(1-\sin\alpha)}$

Ans. 18 B, t_A = 165 s, t_B = 150 s

Ans. 19 (i) 120° (ii) $2/\sqrt{3}$

Ans. 20 $10/\sqrt{3}$ m/s

Ans. 21 $\sqrt{v^2+2gh}$, $\tan^{-1}(\sqrt{2gh}/v)$

Ans. 22 2