Physicsaholics

Exercise

Kinematics- 2D

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Exercise-4

(Subjective Type: Level- 1)

Q 1. The position of a particle is given by

$$\vec{r} = 3.0t\hat{i} - 2.0t^2\hat{j} + 4.0\text{km}$$

where t is in seconds and the coefficients have the proper units for r to be in metres.

(a) Find the v and a of the particle?

(b) What is the magnitude and direction of velocity of the particle at t = 2.0 s

Q 2. The velocity of a particle when it is at its greatest height is $\sqrt{\frac{2}{5}}$ of its velocity when it is at half its greatest height. Find the angle of projection of the particle.

Q 3. A particle moves in xy plane such that $v_x = 50 - 16\,t$ and $y = 100 - 4t^2$ where v_x is in m/s and y is in m. It is also known that x = 0 when t = 0. Determine (i) Acceleration of particle (ii) Velocity of particle when y =0.

Q 4. A particle travels so that its acceleration is given by $\vec{a} = 5\cos t\hat{i} - 3\sin t\hat{j}$. If the particle is located at (–3, 2) at time t = 0 and is moving with a velocity given by $(-3\hat{i} + 2\hat{j})$ .Find

(a) the velocity at time t and

(b) the position vector of the particle at time (t > 0).

Q 5. The position of a particle is given by $x = 7 + 3t^3$ m and $y = 13 + 5t - 9t^2$ m, where x and y are the position coordinates, and t is the time in s. Find the speed (magnitude of the velocity) when the x component of the acceleration is 36 m/s^2.

Q 6. A cricket ball thrown from a height of 1.8 m at an angle of 30º with the horizontal at a speed of 18 m/s is caught by another field's man at a height of 0.6 m from the ground. How far were the two men apart ?

Q 7. The vertical height y and horizontal distance x of a projectile on a certain planet are given by x = (3t)m, y = $(4t - 6t^2)$ m where t is in seconds. Find the speed of projection (in m/s).

Q 8. A particle is projected with a speed of 10 m/s at an angle 37° with the vertical. Find (i) time of flight (ii) maximum height above ground (iii) horizontal range.

Q 9. A particle is thrown with a speed 60 ms^{-1} at an angle 60° to the horizontal. When the particle makes an angle 30° with the horizontal in downward direction, it's speed at that instant is v. What is the value of v^2 in SI units ?

Q 10. A batsman hits the ball at a height 4.0 ft from the ground at projection angle of 45° and the horizontal range is 350 ft. Ball falls on left boundary line, where a 24 ft height fence is situated at a distance of 320 ft. Will the ball clear the fence?

Q 11. A cricketer can throw a ball to a maximum horizontal distance of 100 m. How much high above the ground can the cricketer throw the same ball?

Q 12. A particle is projected upwards with a velocity of 100 m/s at an angle of 60° with the vertical. Find the time when the particle will move perpendicular to its initial direction, taking g =10 m/s^2.

Q 13. A stone is thrown horizontally from a tower. In 0.5 second after the stone began to move, the numerical value of its velocity was 1.5 times its initial velocity. Find the initial velocity of stone.

Q 14. A particle is projected in x-y plane with y-axis along vertical, the point of projection is origin. The equation of a path is $y = \sqrt{3}x - \frac{gx^2}{2}$. Find angle of projection and speed of projection.

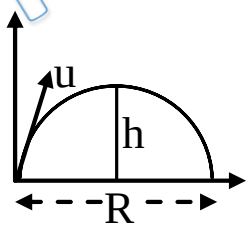
Q 15. (a) Show that for a projectile the angle between the velocity and the x-axis as a function of time is given by

$$\theta(t) = \tan^{-1}\left(\frac{v_{0y} - gt}{v_{ox}}\right)$$

(b) Show that the projection angle q_0 of a projectile launched from the origin is given by

$$\theta_0 = \tan^{-1}\left(\frac{4h_m}{R}\right)$$

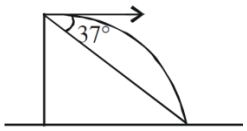
Q 16. If R is the horizontal range and h, the greatest height of a projectile, prove that its initial speed is $\sqrt{\frac{5(16h^2 + R^2)}{4h}}$ [g = 10 m/s^2]



Q 17. A particle is projected in the x-y plane with y-axis along vertical. Two second after projection the velocity of the particle makes an angle 45° with the X-axis. Four second after projection, it moves horizontally. Find the velocity of projection.

Q 18. A bottle was released from rest from a height of 60 m above the ground. Simultaneously, a stone was thrown from a point on the ground 60 m distant horizontally from the bottle, with a velocity *u* at an angle of projection of θ, in a vertical plane containing the bottle. If the stone strikes the bottle 3 s after the instant of projection, find the velocity *u* and the angle θ of projection

Q 19. A ball is thrown horizontally from a cliff such that it strikes ground after 5 s. The line of sight from the point of projection to the point of landing makes an angle of 37° with the horizontal. What is the initial velocity of projection?



Q 20. A shell is fired from a point O at an angle of 60º with a speed of 40 m/s & it strikes a horizontal plane through O, at a point A. The gun is fired a second time with the same angle of elevation but a different speed v. If it hits the target which starts to rise vertically from A with a constant speed $9\sqrt{3}$ m/s at the same instant as the shell is fired, find v. (Take g = 10 m/s^2)

Q 21. A Bomber flying upward at an angle of 53o with the vertical releases a bomb at an altitude of 800 m. The bomb strikes the ground 20 s after its release. Find: [Given sin 53° = 0.8; g = 10 m/s^2]

(i) The velocity of the bomber at the time of release of the bomb.

(ii) The maximum height attained by the bomb.

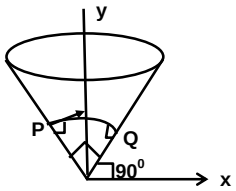
(iii) The horizontal distance travelled by the bomb before it strikes the ground

(iv) The velocity (magnitude & direction) of the bomb just when it strikes the ground.

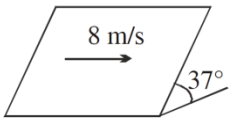
Q 22. A ball is projected at an angle of 30° above the horizontal from the top of a tower and strikes the ground in 5 s at an angle of 45° with the horizontal. Find the height of the tower and the speed with which it was projected.

Q 23. A dive bomber, diving at an angle of 53º with the vertical, releases a bomb at an altitude of 2400 ft. The bomb hits the ground 5.0 s after being released. (a) What is the speed of the bomber? (b) How far did the bomb travel horizontally during its flight? (c) What were the horizontal and vertical components of its velocity just before striking the ground?

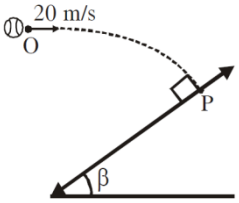
Q 24. A particle is projected from point P with velocity $5\sqrt{2}$ ms^{-1} perpendicular to the surface of a hollow right angle cone whose axis is vertical. It collides at Q normally. The time of the flight of the particle is



Q 25. A ball is projected on smooth inclined plane in direction perpendicular to line of greatest slope with velocity of 8 m/s. Find it's speed after 1 s.

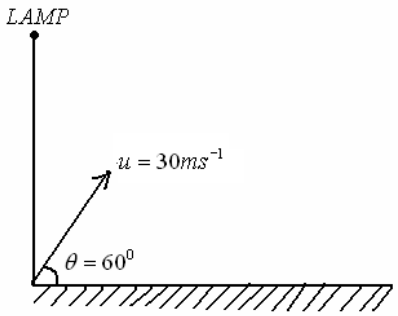


Q 26. A ball is thrown horizontally from a point O with speed 20 m/s as shown. Ball strikes the incline plane along the normal to it after two seconds. Find value of x, if b = p/x (where b is the angle of incline in degree).



Q 27. A particle is projected from base of a lamp post with a velocity of 30 ms^{-1} at an angle 60^0 with horizontal. The height of lamp post is 4 times the maximum height achievable by the particle. When particle is at highest point, find the velocity in ms^{-1} of shadow of particle on ground with respect to particle,

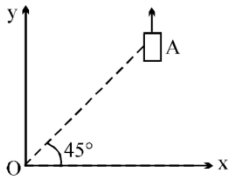
[g = 10 ms^{-2}]



Q 28. A person decided to walk on an escalator which is moving at constant rate (speed). When he moves at the rate 1 step/sec, then he reaches top in 20 steps. Next day he goes 2 steps / sec. and reaches top in 32 steps. If speed of escalator is n steps / sec. Find the value of n.

Q 29. A motorboat going downstream overcame a raft at a point *A; τ* = 60 min later it turned back and after some time passed the raft at a distance l = 6.0 km from the point *A*. Find the flow velocity assuming the duty of the engine to be constant.

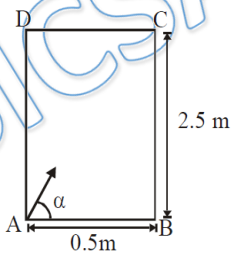
Q 30. On a frictionless horizontal surface, assumed to be the x-y plane, a small trolley. A is moving along a straight line parallel to the y-axis (see figure) with a constant velocity of $(\sqrt{3}-1)$ m/s. At a particular instant, when the line OA makes an angle of 45° with the x-axis, a ball is thrown along the surface from the origin O. 4



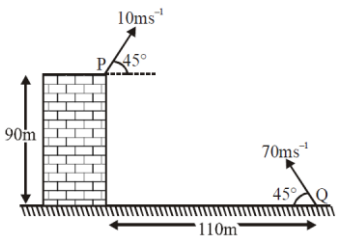
(a) The motion of the ball is observed from the frame of trolley. Calculate the angle θ made by the velocity vector of the ball with the x-axis in this frame.

(b) Find the speed of the ball with respect to the surface, if $\phi = \frac{4\theta}{3}$

Q 31. A cuboidal elevator cabin is shown in the figure. A ball is thrown from point A on the floor of cabin when the elevator is falling under gravity. The plane of motion is ABCD and the angle of projection of the ball with AB, relative to elevator, if the ball collides with point C, is α. Then find the value of $\tan\alpha$.



Q 32. Two particles P and Q are launched simultaneously as shown in figure. Find the minimum distance between particles in meters.



Q 33. A man crosses a river by a boat. If he crosses the river in minimum time he takes 10 minutes with a drift 120 m. If he crosses the river taking shortest path, he takes 12.5 minutes. Assuming $v_{b/r} > v_r$, find

(i) width of the river,

(ii) velocity of the boat with respect to water ($v_{b/r}$)

(iii) speed of the current (v_r)

Q 34. Rain is falling vertically with a speed of 20 m/s relative to air. A person is running in the rain with a velocity of 5 m/s and a wind is also blowing with a speed of 15 m/s (both towards east). Find the angle with the vertical at which the person should hold his umbrella for best protection from rain.

Q 35. A glass wind-screen of adjustable inclination is mounted on a car. The car moves horizontally with a speed of 6 m/s. At what angle α with the vertical should the wind screen be adjusted so that the rain drops falling vertically with 2 m/s strike the wind screen perpendicularly?

Q 36. A motor boat set out at 11 a.m. from a position –6i – 2j and travels at a steady speed of magnitude $\sqrt{53}$ on a direct course to intercept a ship. The ship maintains a steady velocity vector 3i + 4j and at 12 noon is at a position 3i – j . Find

(a) the velocity vector of the motor boat,

(b) the time of interception and

(c) the position vector of point of interception. If distances are measured in kilometres and speeds in kilometers per hour.

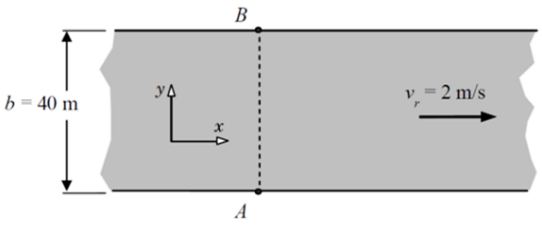
Q 37. Boat moves with velocity 5m/s on still water. It is steered perpendicular to the river current.

(a) Will it reach point B or somewhere else on the other bank?

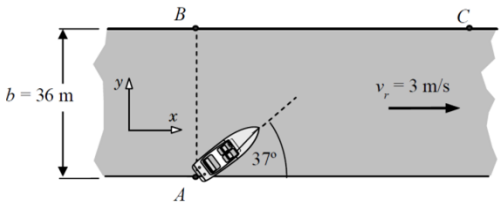
(b) How long will it take to cross the river?

(c) How far down stream, will it reach the other bank?

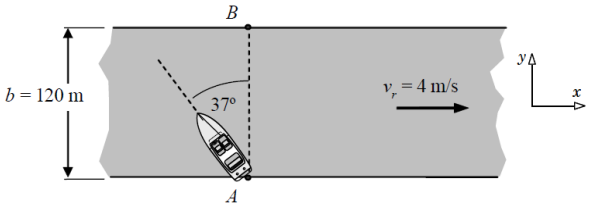
(d) Does it take minimum time in this way?



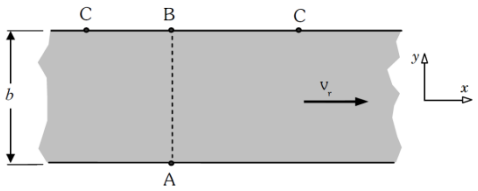
Q 38. Velocity of the boat with respect to river is 10 m/s. From point A it is steered in the direction shown to reach point C. Find the time of the trip and distance between B and C.



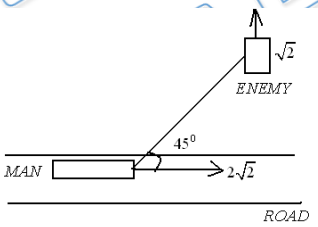
Q 39. Velocity of the boat with respect to river is 10 m/s. From point A it is steered in the direction shown. Where will it reach on the opposite bank?



Q 40. Drift is distance along a river a boat covers in crossing the river. If the boat reaches point C, distance BC is called downstream drift and if the boat reaches point D, distance BD is called upstream drift. To cross a river without drift, what should be relation between v_{br} and v_r. If a boat crosses a river without drift, in which direction must it be steered.



Q 41. A bow man is riding on horse moving with speed of $2\sqrt{2}ms^{-1}$ along a straight road. He aims at his enemy moving perpendicularly to the road at speed of $\sqrt{2}ms^{-1}$. At the instant when he fires the arrow, the line joining man and his enemy makes an angle 45^0 with road. Find the angle with the line perpendicular to the road in degree at which he should aim to hit his enemy. Muzzle velocity (velocity w.r.t. bow) of arrow is $5ms^{-1}$. $\left(take \sin 37^0 = \frac{3}{5}\right)$



Answer Key

Ans. 1 (a) v (t) = $\left(3.0\hat{i}-4.0\hat{j}\right)\hat{a}(t)=-4.0\hat{j}(b)8.54$ (b) 8.54 ms^{-1}, 70° with x-axis

Ans. 2 60º

Ans. 3 (i) $\vec{a}=\left(-16\hat{i}-8\hat{j}\right)$ m/s² (ii) $\vec{v}=\left(-30\hat{i}-40\hat{j}\right)$ m/s

Ans. 4 (a) $\vec{v}=(5\sin t-3)\hat{i}+(3\cos t-1)\hat{j}$, (b) $(2-5\cos t-3t)\hat{i}+(2+3\sin t-t)\hat{j}$

Ans.5 $\sqrt{2257}$ m/s

Ans. 6 30.55 m

Ans. 7 30.55 m

Ans. 8 (i) 1.6 sec (ii) 3.2 m (iii) 9.6 m

Ans. 9 1200

Ans. 10 **yes**

Ans. 11 50 m

Ans. 12 20 s

Ans. 13 4.4 m/s

Ans. 14 60°, 2 m/s.

Ans. 15 (a) $\theta=\tan^{-1}\left(\frac{u_y-gt}{u_x}\right)$ (b) $\theta=\tan^{-1}\left(\frac{4H_m}{R}\right)$

Ans. 16

Ans. 17 $20\sqrt{5}$ m/s

Ans. 18 28.2 m/s, $\theta = 45°$

Ans. 19 $\frac{100}{3}$ m/s

Ans. 20 50 m/s

Ans. 21 (i) 100 m/s (ii) 980 m (iii) 1600 m (iv) $\left(80\hat{i} - 140\hat{j}\right)$

Ans. 22 $u = 50\left(\sqrt{3} - 1\right)$ m/s, H = 2.5($\sqrt{3}$– 1) m

Ans. 23 (a) v_0 = 667 ft/s (b) 2667 ft (c) v_x = 534 ft/s, v_y = 560 ft/s

Ans. 24 1 sec

Ans. 25 10 m/s

Ans. 26 4

Ans. 27 5

Ans. 28 3

Ans. 29 3 km/hr

Ans. 30 (a) 45°, (b) 2 m/sec

Ans. 31 5

Ans. 32 6

Ans. 33 200 m, 20 m/min, 12 m/min

Ans. 34 $\tan^{-1}(1/2)$

Ans. 35 $\tan^{-1}(1/3)$

Ans. 36 (a) 7i + 2j; (b) 12.30p.m, (c) 9/2i + j)

Ans. 37 (a) Somewhere down stream (b) 8 s (c) 16 m (d) Yes

Ans. 38 6 s, 66 m

Ans. 39 30 m upstream

Ans. 40 $v_{br} > v_r, \theta = \sin^{-1}\left(\frac{v_r}{v_{br}}\right)$ upstream of line AB

Ans. 41 8