Topicwise Questions

RELATIVE MOTION

One Dimensional Relative Motion

1. Two trains, each 50 m long are travelling in opposite direction with velocity 10 m/s and 15 m/s. The time of crossing is
   (*a*) 2s (*b*) 4s
   (*c*) $2\sqrt{3}$ s (*d*) $4\sqrt{3}$ s

2. A 210 meter long train is moving due North at a of 25m/s. A small bird is flying due South a little above the train with speed 5m/s. The time taken by the bird to cross the train is
   (*a*) 6 s (*b*) 7 s
   (*c*) 9 s (*d*) 10 s

3. A stone is dropped from a building, and 2 seconds later another stone is dropped. (Both a are dropped from rest.) How far apart are the two stones by the time the first one has reached a speed of 30 m/s ?
   (*a*) 80 m (*b*) 100 m
   (*c*) 60 m (*d*) 40 m

Two Dimensional Relative Motion

4. A bird is flying towards south with a velocity 40km/hr and a train is moving with a velocity 40 km/hr towards east. What is the velocity of the bird w.r.t. an observer in train :–
   (*a*) $40\sqrt{2}$ km/hr. North – East
   (*b*) $40\sqrt{2}$ km/hr. South – East
   (*c*) $40\sqrt{2}$ km/hr. South – West
   (*d*) $40\sqrt{2}$ km/hr. North – West

5. A train is moving towards east and a car is along north, both with same speed. The observed direction of car to the passenger in the train is
   (*a*) East-north direction (*b*) West-north direction
   (*c*) South-east direction (*d*) None of these

Rain Man Problem

6. A man is walking on a road with a velocity 3 km/hr. Suddenly rain starts falling. The velocity of rain is 10 km/hr in vertically downward direction. the relative velocity of the rain with respect to man is :–
   (*a*) $\sqrt{13}$ km/hr (*b*) $\sqrt{7}$ km/hr
   (*c*) $\sqrt{109}$ km/hr (*d*) 13 km/hr

7. A boy is running on the plane road with velocity (v) with a long hollow tube in his hand. The water is falling vertically downwards with velocity (u). At what angle to the vertical, he must incline the tube so that the water drops enters in it without touching its side :–
   (*a*) $\tan^{-1}\left(\frac{v}{u}\right)$ (*b*) $\sin^{-1}\left(\frac{v}{u}\right)$
   (*c*) $\tan^{-1}\left(\frac{u}{v}\right)$ (*d*) $\cos^{-1}\left(\frac{v}{u}\right)$

8. A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/hr then he finds that rain drops are hitting his head vertically, then speed of rain drops with respect to moving man :–
   (*a*) 20 km/hr. (*b*) $10\sqrt{3}$ km/hr.
   (*c*) $\frac{10}{\sqrt{3}}$ km/hr. (*d*) 10 km/hr.

River Man Problem

9. A boat is sent across a river with a velocity of 8 km/hr. If the resultant velocity of boat is 10 km/hr, then velocity of the river is:
   (*a*) 10 km/hr (*b*) 8 km/hr
   (*c*) 6 km/hr (*d*) 4 km/hr

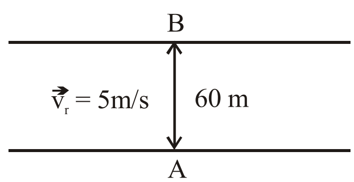
10. A boat is moving with velocity of $3\hat{i}+4\hat{j}$ in river and water is moving with a velocity of $-3\hat{i}-4\hat{j}$ with respect to ground. Relative velocity of boat with respect to water is:
    (*a*) $-6\hat{i}-8\hat{j}$ (*b*) $6\hat{i}+8\hat{j}$
    (*c*) $8\hat{i}$ (*d*) $6\hat{i}$

11. A river is flowing from W to E with a speed of 5 m/min. A man can swim in still water with a velocity 10 m/min. In which direction should the man swim so as to take the shortest possible path to go to the south.
    (*a*) 30° with downstream (*b*) 60° with downstream
    (*c*) 120° with downstream (*d*) South

12. A river is flowing from west to east at a speed of 5 meters per minute. A man on the south bank of the river, capable of swimming at 10 metres per minute in still water, wants to swim across the river in the shortest time. He should swim in a direction

(*a*) due north (*b*) 30° east of north
(*c*) 30° north of west (*d*) 60° east of north

13. A man is crossing a river flowing with velocity of 5 m/s. He reaches a point directly across at a distance of 60 meter in 5 sec. His velocity in still water should be



(*a*) 12 m/s (*b*) 13 m/s
(*c*) 5 m/s (*d*) 10 m/s

Distance of Nearest Approach

14. A body is projected vertically up at t = 0 with a velocity of 98 m/s. Another body is projected from the same point with same velocity after 4 seconds. Both bodies will meet after :–

(*a*) 6 s (*b*) 8 s
(*c*) 10 s (*d*) 12 s

PROJECTILE

Two Dimensional Motion: General Study

15. The point from where a ball is projected is taken as the origin of the coordinate axes. The x and y components of its displacement are given by $x = 6t$ and $y = 8t - 5t^2$. What is the velocity of projection?]

(*a*) 6 m s^{-1} (*b*) 8m s^{-1}
(*c*) 10 m s^{-1} (*d*) 14 m s^{-1}

PROJECTILE MOTION: PROJECTILE HITTING GROUND AT SAME HORIZONTAL LEVEL

16. A projectile fired with initial velocity u at some angle θ has a range R. If the initial velocity be doubled at the same angle of projection, then the range will be

(*a*) 2R (*b*) R/2
(*c*) R (*d*) 4R

17. If the initial velocity of a projectile be doubled, keeping the angle of projection same, the maximum height reached by it will

(*a*) Remain the same
(*b*) Be doubled
(*c*) Be quadrupled
(*d*) Be halved

18. At the top of the trajectory of a projectile, the directions of its velocity and acceleration are

(*a*) Perpendicular to each other
(*b*) Parallel to each other
(*c*) Inclined to each other at an angle of 45°
(*d*) Antiparallel to each other

19. The range of a particle when launched at an angle of 15º with the horizontal is 1.5 km. What is the range of the projectile when launched at an angle of 45° to the horizontal

(*a*) 1.5 km (*b*) 3.0 km
(*c*) 6.0 km (*d*) 0.75 km

20. A stone is projected from the ground with velocity 25 m/s. Two seconds later, it just clears a wall 5 m high. The angle of projection of the stone is ($g = 10m/sec^2$)

(*a*) 30º (*b*) 45º
(*c*) 50.2º (*d*) 60º

21. A projectile thrown with a speed ν at an angle θ has a range R on the surface of earth. For same ν and θ, its range on the surface of moon will be

(*a*) R/6 (*b*) 6R
(*c*) R/36 (*d*) 36 R

22. A particle reaches its highest point when it has covered exactly one half of its horizontal range. The corresponding point on the displacement time graph is characterised by

(*a*) Negative slope and zero curvature
(*b*) Zero slope and negative curvature
(*c*) Zero slope and positive curvature
(*d*) Positive slope and zero curvature

23. If the range of a gun which fires a shell with muzzle speed V is R, then the angle of elevation of the gun is

(*a*) $\cos^{-1}\left(\frac{V^2}{Rg}\right)$ (*b*) $\cos^{-1}\left(\frac{gR}{V^2}\right)$

(*c*) $\frac{1}{2}\left(\frac{V^2}{Rg}\right)$ (*d*) $\frac{1}{2}\sin^{-1}\left(\frac{gR}{V^2}\right)$

PROJECTILE THROWN FROM SOME HEIGHT ABOVE GROUND

24. A stone is just released from the window of a train moving along a horizontal straight track. The stone will hit the ground following

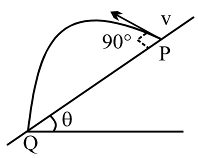
(*a*) Straight path (*b*) Circular path
(*c*) Parabolic path (*d*) Hyperbolic path

25. An aeroplane moving horizontally with a speed of 720 km/h drops a food pocket, while flying at a height of 396.9 m. the time taken by a food pocket to reach the ground and its horizontal range is
(**Take** $g = 9.8$ m/sec^2)
(*a*) 3 sec and 2000 m (*b*) 5 sec and 500 m
(*c*) 8 sec and 1500 m (*d*) 9 sec and 1800 m

Projection on Inclined Plane, Two Dimensional

26. Find time of flight of projectile thrown horizontally with speed 10 ms^{-1} from a long inclined plane which makes an angle of $\theta = 45°$ with the horizontal.
(*a*) $\sqrt{2}$ sec (*b*) $2\sqrt{2}$ sec
(*c*) 2 sec (*d*) none

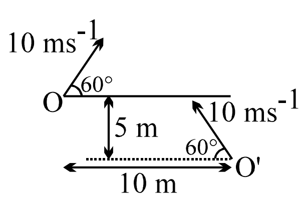
27. If time taken by the projectile to reach Q is T, then PQ =



(*a*) Tv sin θ (*b*) Tv cos θ
(*c*) Tv sec θ (*d*) Tv tan θ

Relative Motion Between Two Projectile

28. Two particles are projected simultaneously from two points O and O' such that 10 m is the horizontal and 5 m is the vertical distance between them as shown in the figure. They are projected at the same inclination 60° to the horizontal with the same velocity 10 ms^{-1}. The time after which their separation becomes minimum is



(*a*) 2.5 sec (*b*) 1 sec
(*c*) 5 sec (*d*) 10 sec

CIRCULAR MOTION

Kinematics of Circular Motion

29. If a particle moves in a circle describing equal angles in equal times, its velocity vector
(*a*) Remains constant
(*b*) Changes in magnituden
(*c*) Changes in direction
(*d*) Changes both in magnitude and direction

30. A particle moves with constant angular velocity in a circle. During the motion its
(*a*) Energy is conserved
(*b*) Momentum is conserved
(*c*) Energy and momentum both are conserved
(*d*) None of the above is conserved

31. The ratio of angular speeds of minute hand and hour hand of a watch is
(*a*) 1 : 12 (*b*) 6 : 1
(*c*) 12 : 1 (*d*) 1 : 6

32. The length of second's hand in a watch is 1 cm. The change in velocity of its tip in 15 seconds is
(*a*) Zero (*b*) $\frac{\pi}{30\sqrt{2}}$ cm / sec
(*c*) $\frac{\pi}{30}$ cm / sec (*d*) $\frac{\pi\sqrt{2}}{30}$ cm / sec

33. What is the value of linear velocity, if $\vec{\omega} = 3\hat{i} - 4\hat{j} + \hat{k}$ and $\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$
(*a*) $6\hat{i} + 2\hat{j} - 3\hat{k}$ (*b*) $-18\hat{i} - 13\hat{j} + 2\hat{k}$
(*c*) $4\hat{i} - 13\hat{j} + 6\hat{k}$ (*d*) $6\hat{i} - 2\hat{j} + 8\hat{k}$

34. A wheel is at rest. Its angular velocity increases uniformly and becomes 80 radian per second after 5 second. The total angular displacement is:
(*a*) 800 rad (*b*) 400 rad
(*c*) 200 rad (*d*) 100 rad

35. A wheel is of diameter 1m. If it makes 30 revolutions/sec., then the linear speed of a point on its circumference will be.
(*a*) 30π m/s (*b*) π m/s
(*c*) 60π m/s (*d*) π/2 m/s

36. In uniform circular motion (angular momentum $L = m\vec{r} \times \vec{v}$)
(*a*) Both the angular velocity and the angular momentum vary
(*b*) The angular velocity varies but the angular momentum remains constant.
(*c*) Both the angular velocity and the angular momentum stay constant
(*d*) The angular momentum varies but the angular velocity remains constant.

Centripetal/Tangential/Net Acceleration

37. A body is moving in a circular path with a constant speed. It has
(*a*) A constant velocity
(*b*) A constant acceleration
(*c*) An acceleration of constant magnitude
(*d*) An acceleration which varies with time

38. Two bodies of mass 10 kg and 5 kg moving in concentric orbits of radii R and r such that their periods are the same. Then the ratio between their centripetal acceleration is

(*a*) R/r (*b*) r/R

(*c*) R^2/r^2 (*d*) r^2/R^2

39. A car travels north with a uniform velocity. It goes over a piece of mud which sticks to the tyre. The particles of the mud, as it leaves the ground are thrown

(*a*) Vertically upwards (*b*) Vertically inwards

(*c*) Towards north (*d*) Towards south

40. A stone is tied to one end of a string 50 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 10 revolutions in 20 s, what is the magnitude of acceleration of the stone

(*a*) 493 cm/s^2 (*b*) 720 cm/s^2

(*c*) 860 cm/s^2 (*d*) 990 cm/s^2

41. Two particles P and Q are located at distances r_P and r_Q respectively from the axis of a rotating disc such that $r_P > r_Q$:

(*a*) Both P and Q have the same acceleration

(*b*) Both P and Q do not have any acceleration

(*c*) P has greater acceleration than Q

(*d*) Q has greater acceleration than P

42. A string breaks if its tension exceeds 10 newtons. A stone of mass 250 gm tied to this string of length 10 cm is rotated in a horizontal circle. The maximum angular velocity of rotation can be.

(*a*) 20 rad/s (*b*) 40 rad/s

(*c*) 100 rad/s (*d*) 200 rad/s

43. A particle moving along a circular path due to a centripetal force having constant magnitude is an example of motion with:

(*a*) constant speed and velocity

(*b*) variable speed and velocity

(*c*) variable speed and constant velocity

(*d*) constant speed and variable velocity.

44. The formula for centripetal acceleration in a circular motion is.

(*a*) $\vec{\alpha} \times \vec{r}$ (*b*) $\vec{\omega} \times \vec{v}$

(*c*) $\vec{\alpha} \times \vec{v}$ (*d*) $\vec{\omega} \times \vec{r}$

45. A particle moves in a circular orbit under the action of a central attractive force inversely proportional to the distance 'r'. The speed of the particle is.

(*a*) Proportional to r^2

(*b*) Independent of r

(*c*) Proportional to r

(*d*) Proportional to 1/r

46. A particle of mass m is moving with constant velocity $\vec{v}$ on smooth horizontal surface. A constant force $\vec{F}$ starts acting on particle perpendicular to velocity v. Radius of curvature after force F start acting is :

(*a*) $\dfrac{mv^2}{F}$ (*b*) $\dfrac{mv^2}{F\cos\theta}$

(*c*) $\dfrac{mv^2}{F\sin\theta}$ (*d*) none of these

47. If the radii of circular paths of two particles of same masses are in the ratio of 1 : 2, then in order to have same centripetal force, their speeds should be in the ratio of :

(*a*) 1 : 4 (*b*) 4 : 1

(*c*) $1:\sqrt{2}$ (*d*) $\sqrt{2}:1$

48. A particle is moving in a horizontal circle with constant speed. It has constant

(*a*) Velocity (*b*) Acceleration

(*c*) Kinetic energy (*d*) Displacement

49. What happens to the centripetal acceleration of a revolving body if you double the orbital speed v and halve the angular velocity ω ?

(*a*) the centripetal acceleration remains unchanged

(*b*) the centripetal acceleration is halved

(*c*) the centripetal acceleration is doubled

(*d*) the centripetal acceleration is quadrupled

50. A particle is moving along a circular path. the angular velocity, linear velocity, angular acceleration and centripetal acceleration of the particle at any instant respectively are $\vec{\omega}, \vec{v}, \vec{\alpha}$ and $\vec{a}_c$. Which of the following relations is not correct?

(*a*) $\vec{\omega} \perp \vec{v}$ (*b*) $\vec{\omega} \perp \vec{\alpha}$

(*c*) $\vec{\omega} \perp \vec{a}_c$ (*d*) $\vec{v} \perp \vec{a}_c$

51. A particle is moving in circular path with constant tangential acceleration, time t after the begining of motion the direction of net acceleration is at 45° to radius vector at the instant. The angular acceleration of the particle at time 't' is proportional to:

(*a*) $\dfrac{1}{t}$ (*b*) $\dfrac{1}{t^2}$

(*c*) $\dfrac{3}{t}$ (*d*) t^0

52. A car is travelling with linear velocity v on a circular road of radius r. If it is increasing it speed at the rate of 'a' metre/sec^2, then the resultant acceleration will be-

(*a*) $\sqrt{\left(\dfrac{v^2}{r^2} - a^2\right)}$ (*b*) $\sqrt{\left(\dfrac{v^4}{r^2} + a^2\right)}$

(*c*) $\sqrt{\left(\dfrac{v^4}{r^2} - a^2\right)}$ (*d*) $\sqrt{\left(\dfrac{v^2}{r^2} + a^2\right)}$

Mechanics of Circular Motion

53. If the overbridge is concave instead of being convex, the thrust on the road at the lowest position will be

(*a*) $mg + \frac{mv^2}{r}$ (*b*) $mg - \frac{mv^2}{r}$

(*c*) $\frac{m^2v^2g}{r}$ (*d*) $\frac{v^2g}{r}$

54. A motor cyclist moving with a velocity of 72 km/hour on a flat road takes a turn on the road at a point where the radius of curvature of the road is 20 meters. The acceleration due to gravity is 10 m/sec^2. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle greater than

(*a*) $\theta = \tan^{-1} 6$ (*b*) $\theta = \tan^{-1} 2$

(*c*) $\theta = \tan^{-1} 25.92$ (*d*) $\theta = \tan^{-1} 4$

55. The force required to keep a body in uniform circular motion is

(*a*) Centripetal force (*b*) Centrifugal force

(*c*) Resistance (*d*) None of the above

56. The magnitude of the centripetal force acting on a body of mass m executing uniform motion in a circle of radius r with speed v is

(*a*) mvr (*b*) mv^2/r

(*c*) v/r^2m (*d*) v/rm

57. A ball of mass 0.25 kg attached to the end of a string of length 1.96 m is moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which the ball can be moved

(*a*) 14 m/s (*b*) 3 m/s

(*c*) 3.92 m/s (*d*) 5 m/s

58. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $(-k/r^2)$, the total energy is

(*a*) $-\frac{k}{2r}$ (*b*) $-\frac{k}{r}$

(*c*) $-\frac{2k}{r}$ (*d*) $-\frac{4k}{r}$

59. A car when passes through a convex bridge exerts a force on it which is equal to

(*a*) $Mg + \frac{Mv^2}{r}$ (*b*) $\frac{Mv^2}{r}$

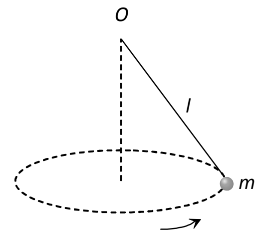
(*c*) Mg (*d*) $Mg - \frac{Mv^2}{r}$

60. An unbanked curve has a radius of 60 m. The maximum speed at which a car can make a turn if the coefficient of static friction is 0.75, is

(*a*) 2.1 m/s (*b*) 14 m/s

(*c*) 21 m/s (*d*) 7 m/s

61. A point mass m is suspended from a light thread of length *l*, fixed at O, is whirled in a horizontal circle at constant speed as shown. From your point of view, stationary with respect to the mass, the forces on the mass are



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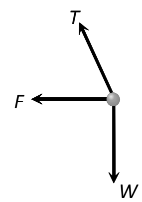

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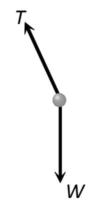

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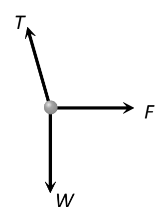

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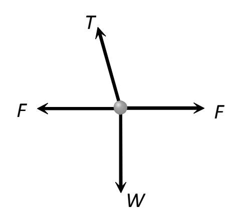


62. A stone of mass 0.5 kg tied with a string of length 1 metre is moving in a circular path with a speed of 4 m/sec. The tension acting on the string in newton is -

(*a*) 2 (*b*) 8

(*c*) 0.2 (*d*) 0.8

63. A particle of mass m is executing a uniform motion along a circular path of radius r. If the magnitude of its linear momentum is p, the radial force acting on the particle will be.

(*a*) pmr (*b*) rm/p

(*c*) mp^2/r (*d*) p^2/mr

64. When the road is dry and the coefficient of friction is μ, the maximum speed of a car in a circular path is 10 m/s, if the road becomes wet and μ' = μ/2. What is the maximum speed permitted ?

(*a*) 5 m/s (*b*) 10 m/s

(*c*) $10\sqrt{2}$ m/s (*d*) $5\sqrt{2}$ m/s

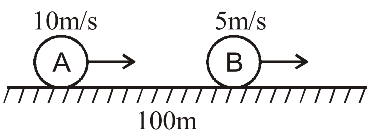
Learning Plus

RELATIVE MOTION

1. Two trains each of length 50 m are approaching each other on parallel rails. Their velocities are 10 m/sec and 15 m/sec. They will cross each other in -

(*a*) 2 sec (*b*) 4 sec
(*c*) 10 sec (*d*) 6 sec

2. 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 time taken by A to Meet B



(*a*) 18 sec. (*b*) 16 sec.
(*c*) 20 sec. (*d*) 17 sec.

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

4. 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?

(*a*) 50 ms^{-1} (*b*) 40 ms^{-1}
(*c*) 30 ms^{-1} (*d*) 20 ms^{-1}

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

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 m s^{-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. Two cars get closer by 9 m every second while travelling in the opposite directions. They get closer by 1 m every second while travelling in the same directions. 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}

8. A jet airplane travelling from east to west at a speed of 500 km h^{-1} ejects 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

9. 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

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

(*a*) zero (*b*) $\pi/4$
(*c*) $\pi/2$ (*d*) π

11. 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°

12. 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 rain if it is falling vertically downward -

(*a*) 5 kmh^{-1} (*b*) 4 kmh^{-1}
(*c*) 3 kmh^{-1} (*d*) 1 kmh^{-1}

13. To man running at a speed of 25 m/sec,the rain drops appear to be falling at an angle of 45° from the vertical. If the rain drops are actually falling vertically downwards, then velocity in m/sec is

(*a*) 25 (*b*) $25\sqrt{3}$
(*c*) $25\sqrt{2}$ (*d*) 4

14. 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*) $\sqrt{41}$

15. A boat can go along a lake and return in time T_0 at a speed V. On a rough day there is uniform current at speed u to help the onward journey and impede the return journey. If the time taken to go along and return on the rough day be T, then T/T_0 =

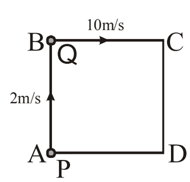
(*a*) $1-\frac{u^2}{V^2}$ (*b*) $\frac{1}{1-\frac{u^2}{V^2}}$

(*c*) $1+\frac{u^2}{V^2}$ (*d*) $\frac{1}{1+\frac{u^2}{V^2}}$

16. Two boats were going down stream with different velocities. When one overtook the other a plastic ball was dropped from one of the boats into water. Some time later both boats turned back simultaneously & went at the same speeds as before (relative to the water) towards the spot where the ball had been dropped. Which boat will reach the ball first?

(*a*) the boat which has greater velocity (relative to water)
(*b*) the boat which has lesser velocity (relative to water)
(*c*) both will reach the ball simultaneously
(*d*) cannot be decided unless we know the actual values of the velocities and the time after which they turned around

17. 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 when they will meet for the first time.



(*a*) 2 sec (*b*) 3 sec

(*c*) 1 sec (*d*) 6 sec

PROJECTILE

18. At an instant t , the co-ordinates of a particle are $x = at^2$, $y = bt^2$ and z = 0 , then its speed at the instant t will be

(*a*) $t\sqrt{a^2+b^2}$ (*b*) $2t\sqrt{a^2+b^2}$

(*c*) $\sqrt{a^2+b^2}$ (*d*) $2t^2\sqrt{a^2+b^2}$

19. A bullet is fired horizontally from a rifle at a distant target. Ignoring the effect of air resistance, which of the following is correct? Horizontal Acceleration and Vertical Acceleration are given by:

(*a*) $10\ ms^{-2}$, $10\ ms^{-2}$ (*b*) $10\ ms^{-2}$, $0\ ms^{-2}$

(*c*) $0\ ms^{-2}$, $10\ ms^{-2}$ (*d*) $0\ ms^{-2}$, $0\ ms^{-2}$

20. It was calculated that a shell when fired from a gun with a certain velocity and at an angle of elevation $\frac{5\pi}{36}$ rad should strike a given target in the same horizontal plane. In actual practice, it was found that a hill just prevented the trajectory. At what angle of elevation should the gun be fired to hit the target.

(*a*) $\frac{5\pi}{36}$ rad (*b*) $\frac{11\pi}{36}$ rad

(*c*) $\frac{7\pi}{36}$ rad (*d*) $\frac{13\pi}{36}$ rad.

21. A projectile is thrown with a speed v at an angle θ with the vertical. Its average velocity between the instants it crosses half the maximum height is

(*a*) v sin θ, horizontal and in the plane of projection
(*b*) v cos θ, horizontal and in the plane of projection
(*c*) 2v sin θ, horizontal and perpendicular to the plane of projection
(*d*) 2v cos θ, vertical and in the plane of projection.

22. During projectile motion, acceleration of a particle at the highest point of its trajectory is

(*a*) g
(*b*) zero
(*c*) less than g
(*d*) dependent upon projection velocity

23. The maximum range of a projectile is 22 m. When it is thrown at an angle of 15° with the horizontal, its range will be-

(*a*) 22 m (*b*) 6m

(*c*) 15 m (*d*) 11 m

24. The equation of projectile is $y = 16x - \frac{5x^2}{4}$. The horizontal range is-

(*a*) 16 m (*b*) 8m

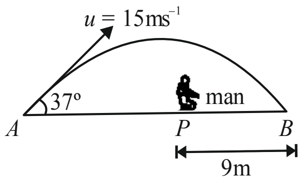
(*c*) 3.2 m (*d*) 12.8 m

25. If four balls A, B, C, D are projected with same speed at angles of 15°, 30°, 45° and 60° with the horizontal respectively, the two balls which will fall at the same place will be-

(*a*) *a* and *b* (*b*) *a* and *d*

(*c*) *b* and *d* (*d*) *a* and *c*

26. A ball is hit by a batsman at an angle of 37° as shown in figure. The man standing at P should run at what minimum velocity so that he catches the ball before it strikes the ground. Assume that height of man is negligible in comparison to maximum height of projectile.



(*a*) 3 ms^{-1} (*b*) 5 ms^{-1}
(*c*) 9 ms^{-1} (*c*) 12 ms^{-1}

27. Suppose a player hits several baseballs. Which baseball will be in the air for the longest time?
(*a*) The one with the farthest range.
(*b*) The one which reaches maximum height
(*c*) The one with the greatest initial velocity
(*d*) The one leaving the bat at 45° with respect to the ground.

28. A particle is projected from the ground with velocity u at angle θ with horizontal. The horizontal range, maximum height and time of flight are R, H and T respectively. They are given by,

$$R = \frac{u^2 \sin 2\theta}{g}, \; H = \frac{u^2 \sin^2 \theta}{2g} \text{ and } T = \frac{2u \sin\theta}{g}$$

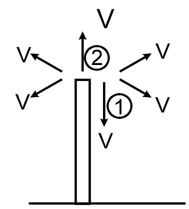
Now keeping u as fixed, θ is varied from 30° to 60°. Then,

(*a*) R will first increase then decrease, H will increase and T will decrease
(*b*) R will first increase then decrease while H and T both will increase
(*c*) R will decrease while H and T will increase
(*d*) R will increase while H and T will increase

29. A point mass is projected, making an acute angle with the horizontal. If angle between velocity $\vec{v}$ and acceleration $\vec{g}$ is θ at any time t during the motion, then θ is given by
(*a*) $0° < \theta < 90°$ (*b*) $\theta = 90°$
(*c*) $\theta < 90°$ (*d*) $0° < \theta < 180°$

30. One stone is projected horizontally from a 20 m high cliff with an initial speed of 10 ms^{-1}. A second stone is simultaneously dropped from that cliff. Which of the following is true?
(*a*) Both strike the ground with the same speed.
(*b*) The ball with initial speed 10 ms^{-1} reaches the ground first.
(*c*) Both the balls hit the ground at the different time.
(*d*) Both strike the ground with different speed

31. Particles are projected from the top of a tower with same speed at different angles as shown. Which of the following are True ?



(*a*) All the particles would strike the ground with (same) speed.
(*b*) All the particles would strike the ground with (same) speed simultaneously.
(*c*) Particle 1 will be the first to strike the ground.
(*d*) (*a*) & (*c*) both

32. A body is projected horizontally from the top of a tower with initial velocity 18 ms^{-1}. It hits the ground at angle 45°. What is the vertical component of velocity when it strikes the ground?
(*a*) $18\sqrt{2}$ ms^{-1} (*b*) 18 ms^{-1}
(*c*) $9\sqrt{2}$ ms^{-1} (*d*) 9 ms^{-1}

33. A ball is projected from a certain point on the surface of a planet at a certain angle with the horizontal surface. The horizontal and vertical displacement x and y varies with time t in second as:

$x = 10\sqrt{3}\,t$ and $y = 10t - t^2$

The maximum height attained by the ball is
(*a*) 100m (*b*) 75m
(*c*) 50m (*d*) 25m

34. The angle of projection of a body is 15° . The other angle for which the range is the same as the first one is equal to-
(*a*) 30° (*b*) 45°
(*c*) 60° (*d*) 75°

35. An aeroplane is flying at a height of 1960 m in horizontal direction with a velocity of 360 km/hr. When it is vertically above the point. A on the ground, it drops a bomb. The bomb strikes a point B on the ground, then the time taken by the bomb to reach the ground is-
(*a*) $20\sqrt{2}$ sec (*b*) 20 sec
(*c*) $10\sqrt{2}$ sec (*d*) 10 sec

36. A ball is projected from top of a tower with a velocity of 5 m/s at an angle of 53° to horizontal. Its speed when it is at a height of 0.45 m from the point of projection is
(*a*) 2 m/s
(*b*) 3 m/s
(*c*) 4 m/s
(*d*) data insufficient

37. An aeroplane flying at a constant velocity releases a bomb. As the bomb drops down from the aeroplane.
(*a*) it will always be vertically below the aeroplane
(*b*) it will always be vertically below the aeroplane only if the aeroplane is flying horizontally
(*c*) it will always be vertically below the aeroplane only if the aeroplane is flying at an angle of 45° to the horizontal.
(*d*) it will gradually fall behind the aeroplane if the aeroplane is flying horizontally

38. A particle is projected at angle 37° with the incline plane in upward direction with speed 10 m/s. The angle of incline plane is given 53°. Then the maximum height above the incline plane attained by the particle will be
(*a*) 3m (*b*) 4m
(*c*) 5m (*d*) zero

39. The velocity at the maximum height of a projectile is half of its initial velocity u. Its range on the horizontal plane is:
(*a*) $\frac{2u^2}{3g}$ (*b*) $\frac{\sqrt{3}\,u^2}{2g}$
(*c*) $\frac{u^2}{3g}$ (*d*) $\frac{u^2}{2g}$

CIRCULAR MOTION

40. Two racing cars of masses m_1 and m_2 are moving in circles of radii r and 2r respectively ; their angular speeds are equal. The ratio of the time taken by cars to complete one revolution is :
(*a*) $m_1 : m_2$ (*b*) 1 : 2
(*c*) 1 : 1 (*d*) $m_1 : 2m_2$

41. The second's hand of a watch has length 6 cm. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be :
(*a*) 2π & 0 mm/s (*b*) $2\sqrt{2}\,\pi$ & 4.44 mm/s
(*c*) $2\sqrt{2}\,\pi$ & 2π mm/s (*d*) 2π & $2\sqrt{2}\,\pi$ mm/s

42. A wheel is subjected to uniform angular a cceleration about its axis. Initially its angular velocity is zero. In the first 2 sec, it rotates through an angle θ_1 ; in the next 2 sec, it rotates through an additional angle θ_2. The ratio of θ_2 / θ_1 is-
(*a*) 1 (*b*) 2
(*c*) 3 (*d*) 5

43. The ratio of angular speed of hours hand and seconds hand of a clock is-
(*a*) 1 : 1 (*b*) 1 : 60
(*c*) 1 : 720 (*d*) 3600 : 1

44. The linear and angular acceleration of a particle are 10 m/sec^2 and 5 rad/sec^2 respectively it will be at a distance from the axis of rotation -
(*a*) 50m (*b*) 1/2 m
(*c*) 1m (*d*) 2m

45. The earth, radius 6400 km, makes one revolution about its own axis in 24 hours. The centripetal acceleration of a point on its equator is nearly -
(*a*) $340\frac{\text{cm}}{\text{sec}^2}$ (*b*) $3.4\frac{\text{cm}}{\text{sec}^2}$
(*c*) $34\frac{\text{cm}}{\text{sec}^2}$ (*d*) $0.34\frac{\text{cm}}{\text{sec}^2}$

46. A particle moves in a circle of radius 25 cm at two revolutions per second. The acceleration of particle in m/s^2 is -
(*a*) π^2 (*b*) $8\pi^2$
(*c*) $4\pi^2$ (*d*) $2\pi^2$

47. If angular velocity of a disc depends an angle rotated θ as $\omega = \theta^2 + 2\theta$, then its angular acceleration α at $\theta = 1$ rad is
(*a*) 8 rad/sec^2 (*b*) 10 rad/sec^2
(*c*) 12 rad/sec^2 (*d*) None

48. A stone of mass of 16 kg is attached to a string 144 m long and is whirled in a horizontal smooth surface. The maximum tension the string can withstand is 16 N. The maximum speed of revolution of the stone without breaking it, will be :
(*a*) 20 ms^{-1} (*b*) 16 ms^{-1}
(*c*) 14 ms^{-1} (*d*) 12 ms^{-1}

49. On horizontal smooth surface a mass of 2 kg is whirled in a horizontal circle by means of a string at an initial angular speed of 5 revolutions per minute. Keeping the radius constant the tension in the string is doubled. The new angular speed is nearly :
(*a*) 14 rpm (*b*) 10 rpm
(*c*) 2.25 rpm (*d*) 7 rpm

50. A coin placed on a rotating turntable just slips if it is placed at a distance of 16 cm from the centre. If the angular velocity of the turntable is doubled, it will just slip at a distance of
(*a*) 1 cm (*b*) 2 cm
(*c*) 4 cm (*d*) 8 cm

51. A stone is projected with speed u and angle of projection is θ. Find radius of curvature at t = 0.
(*a*) $\frac{u^2\cos^2\theta}{g}$ (*b*) $\frac{u^2}{g\sin\theta}$
(*c*) $\frac{u^2}{g\cos\theta}$ (*d*) $\frac{u^2\sin^2\theta}{g}$

52. In a circus, stuntman rides a motorbike in a circular track of radius R in the vertical plane. The minimum speed at highest point of track will be :

(*a*) $\sqrt{2gR}$ (*b*) 2gR

(*c*) $\sqrt{3gR}$ (*d*) $\sqrt{gR}$

53. A stone tied to a string is rotated in a vertical plane. If mass of the stone is m, the length of the string is r and the linear speed of the stone is v when the stone is at its lowest point, then the tension in the string at the lowest point will be :

(*a*) $\frac{mv^2}{r}+mg$ (*b*) $\frac{mv^2}{r}-mg$

(*c*) $\frac{mv^2}{r}$ (*d*) mg

54. A curved section of a road is banked for a speed v. If there is no friction between road and tyres of the car, then :

(*a*) car is more likely to slip at speeds higher than v than speeds lower than v

(*b*) car can remain in static equilibrium on the curved section

(*c*) car will not slip when moving with speed v

(*d*) none of the above

55. A man is standing on a rough ($\mu = 0.5$) horizontal disc rotating with constant angular velocity of 5 rad/sec. At what distance from centre should he stand so that he does not slip on the disc?

(*a*) $R \le 0.2$ m (*b*) $R > 0.2$ m

(*c*) $R > 0.5$ m (*d*) $R > 0.3$ m

56. A road is banked at an angle of 30° to the horizontal for negotiating a curve of radius $10\sqrt{3}$ m. At what velocity will a car experience no friction while negotiating the curve?

(*a*) 54 km/hr (*b*) 72 km/hr

(*c*) 36 km/hr (*d*) 18 km/hr

57. A car moving on a horizontal road may be thrown out of the road in taking a turn :

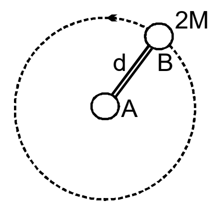
(*a*) By the gravitational force

(*b*) Due to lack of sufficient centripetal force

(*c*) Due to friction between road and the tyre

(*d*) Due to reaction of earth

58. The dumbell is placed on a frictionless horizontal table. Sphere A is attached to a frictionless pivot so that B can be made to rotate about A with constant angular velocity. If B makes one revolution in period P, the tension in the rod is



(*a*) $\frac{4\pi^2 Md}{P^2}$ (*b*) $\frac{8\pi^2 Md}{P^2}$

(*c*) $\frac{4\pi^2 Md}{P}$ (*d*) $\frac{2Md}{P}$

59. A string can bear a maximum tension of 100 Newton without breaking. A body of mass 1 kg is attached to one end of 1 m length of thin string and it is revolved in a horizontal plane. The maximum linear velocity which can be imparted to the body without breaking the string, will be -

(*a*) 10 m/s (*b*) 1 m/s

(*c*) 100 m/s (*d*) 1000 m/s

60. A cyclist is moving on a circular track of radius 80 m with a velocity of 72 km/hr. He has to lean from the vertical approximately through an angle

(*a*) $\tan^{-1}(1/4)$ (*b*) $\tan^{-1}(1)$

(*c*) $\tan^{-1}(1/2)$ (*d*) $\tan^{-1}(2)$

Advanced Level Multiconcept Questions

MCQ/COMPREHENSION/MATCHING/ NUMERICAL RELATIVE MOTION

1. A man on a rectilinearly moving cart, facing the direction of motion, throws a ball straight up with respect to himself

(*a*) The ball will always return to him

(*b*) The ball will never return to him

(*c*) The ball will return to him if the cart moves with constant velocity

(*d*) The ball will fall behind him if the cart moves with some positive acceleration

2. A train is running with uniform velocity in east direction. A car is running on a road parallel to the track with uniform speed. After some time, the road becomes perpendicular to railway track. The car driver notices that initial speed of train with respect to itself was 7 m/s and later on it became 13 m/s. What can be the true speed of the driver ?

(*a*) 12 m/s (*b*) 5 m/s

(*c*) 13 m/s (*d*) 7 m/s

3. State which of the following statement(s) is/are false.
   (*a*) If two particles are neither approaching nor separating from each other, then their relative velocity is zero.
   (*b*) If relative velocity of particle B with respect to A is $\vec{v}_1$, relative velocity of particle C with respect to B is $\vec{v}_2$ and particle A moves with velocity $\vec{v}_0$ with respect to ground, then the velocity of C with respect to ground cannot be zero. (assuming $\vec{v}_1$, $\vec{v}_2$ & $\vec{v}_0$ to be non zero)
   (*c*) Four dogs are running along a line in the same direction, such that each is running relative to the dog in front of him with equal speed. Then the rate of separation between the third and the first dog is same as that of the fourth & the second dog. (where first, second, third and fourth are taken in order)
   (*d*) At some instant of time at a place, two particles are observed and it is found that their relative velocity is zero. Then they will remain stationary with respect to each other.
4. A block is thrown with a velocity of 2 ms^{-1} (relative to ground) on a belt, which is moving with velocity 4 ms^{-1} in opposite direction of the initial velocity of block. If the block stops slipping on the belt after 4 sec of the throwing then choose the correct statements (s)
   (*a*) Displacement with respect to ground is zero after 2.66s and magnitude of displacement with respect to ground is 12 m after 4 sec.
   (*b*) Magnitude of displacement with respect to ground in 4 sec is 4 m.
   (*c*) Magnitude of displacement with respect to belt in 4 sec is 12 m.
   (*d*) Displacement with respect to ground is zero in 8/3 sec.
5. A river is flowing with a velocity of 2 m/s. A boat is moving downstream along the river. Velocity of the boat in still water is 3 m/s. A person standing on the boat throws a ball (w.r.t. himself) in a plane-perpendicular to the direction of motion of the boat with 10 m/s at 60° with the horizontal. When the ball reaches highest point of its path.
   (*a*) The speed of ball w.r.t. man standing on boat is 5 m/s
   (*b*) The speed of ball w.r.t. river is 3 m/s
   (*c*) The speed of ball w.r.t. river is 0 m/s
   (*d*) The speed of ball w.r.t. ground is $5\sqrt{2}$ m/s
6. Two particles are projected from the same point with the same speed in the same vertical plane at different angles with the horizontal. A frame of reference is fixed to one particle. The position vector of the other particle as observed from the frame is $\vec{r}$. Which of the following statements is/are **incorrect**?
   (*a*) $\vec{r}$ is a constant vector
   (*b*) $\vec{r}$ changes in magnitude and direction with time
   (*c*) the magnitude of $\vec{r}$ increases linearly with time, its direction does not change
   (*d*) the direction of $\vec{r}$ changes with time, its magnitude may or may not change depending on the angles of projection.
7. Consider a shell that has a muzzle velocity of 45 ms^{-1} fired from the tail gun of an airplane moving horizontally with a velocity of 215 ms^{-1}. The tail gun can be directed at any angle with the vertical in the plane of motion of the airplane. The shell is fired when the plane is above point A on ground, and the plane is above point B on ground when the shell hits the ground. (Assume for simplicity that the Earth is flat)
   (*a*) Shell may hit the ground at point A.
   (*b*) Shell may hit the ground at point B.
   (*c*) Shell may hit a point on earth which is behind point A.
   (*d*) Shell may hit a point on earth which is ahead of point B.

PROJECTILE

8. A projectile is projected at an angle α (> 45°) with an initial velocity u. The time t at which its horizontal component will equal the vertical component in magnitude:
   (*a*) $t = \frac{u}{g}(\cos\alpha - \sin\alpha)$
   (*b*) $t = \frac{u}{g}(\cos\alpha + \sin\alpha)$
   (*c*) $t = \frac{u}{g}(\sin\alpha - \cos\alpha)$
   (*d*) $t = \frac{u}{g}(\sin^2\alpha - \cos^2\alpha)$
9. At what angle should a body be projected with a velocity 24 ms^{-1} just to pass over the obstacle 14 m high at a distance of 24 m. [Take g = 10 ms^{-2}]
   (*a*) $\tan\theta = 19/5$ (*b*) $\tan\theta = 1$
   (*c*) $\tan\theta = 3$ (*d*) $\tan\theta = 2$

10. Choose the correct alternative (s)

(*a*) If the greatest height to which a man can throw a stone is h, then the greatest horizontal distance upto which he can throw the stone is 2h.

(*b*) The angle of projection for a projectile motion whose range R is n times the maximum height is $\tan^{-1}(4/n)$

(*c*) The time of flight T and the horizontal range R of a projectile are connected by the equation $gT^2 = 2R\tan\theta$ where θ is the angle of projection.

(*d*) A ball is thrown vertically up. Another ball is thrown at an angle θ with the vertical. Both of them remain in air for the same period of time. Then the ratio of heights attained by the two ball 1 : 1.

11. A ball is rolled off along the edge of a horizontal table with velocity 4 m/s. It hits the ground after time 0.4s. Which of the following are correct?

(*a*) The height of the table is 0.8 m

(*b*) It hits the ground at an angle of 60° with the vertical

(*c*) It covers a horizontal distance 1.6 m from the table

(*d*) It hits the ground with vertical velocity 4 m/s

CIRCULAR MOTION

12. A person applies a constant force $\vec{F}$ on a particle of mass m and finds that the particle moves in a circle of radius r with a uniform speed v as seen (in the plane of motion) from an inertial frame of reference.

(*a*) This is not possible.

(*b*) There are other forces on the particle.

(*c*) The resultant of the other forces is $\frac{mv^2}{r}$ towards the centre.

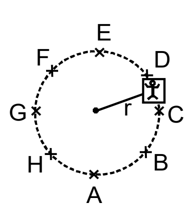
(*d*) The resultant of the other forces varies in magnitude as well as in direction.

13. Which of the following quantities may remain constant during the motion of an object along a curved path:

(*a*) speed (*b*) velocity

(*c*) acceleration (*d*) magnitude of acceleration

14. A machine, in an amusement park, consists of a cage at the end of one arm, hinged at O. The cage revolves along a vertical circle of radius r (ABCDEFGH) about its hinge O, at constant linear speed $v = \sqrt{gr}$. The cage is so attached that the man of weight 'w' standing on a weighing machine, inside the cage, is always vertical. Then which of the following is correct



(*a*) the reading of his weight on the machine is the same at all positions

(*b*) the weight reading at A is greater than the weight reading at E by 2 w.

(*c*) the weight reading at G = w

(*d*) the ratio of the weight reading at E to that at A=0

(*e*) the ratio of the weight reading at A to that at C=2

15. A simple pendulum of length L and mass (bob) M is oscillating in a plane about a vertical line between angular limits –φ to φ. For an angular displacement θ, [|θ| < φ] the tension in the string and velocity of the bob are T and v respectively. The following relations hold good under the above conditions :

(*a*) $T\cos\theta = Mg$

(*b*) $T - Mg\cos\theta = \frac{Mv^2}{L}$

(*c*) Tangential acc. = $g\sin\theta$

(*d*) $T = Mg\cos\theta$

16. A car of mass m attempts to go on the circular road of radius r, which banked for a speed of 36 km/hr. The friction coefficient between the tyre and the road is negligible.

(*a*) The car cannot make a turn without skidding.

(*b*) If the car turns at a speed less than 36 km/hr, it will slip down

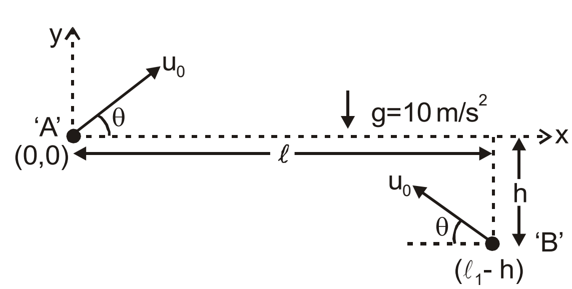
(*c*) If the car turns at the constant speed of 36 km/hr, the force by the road on the car is equal to $\frac{mv^2}{r}$

(*d*) If the car turns at the correct speed of 36 km/hr, the force by the road on the car is greater than mg as well as greater than $\frac{mv^2}{r}$

RELATIVE MOTION

Comprehension – 1 (Q.17 to Q.19)

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



17. 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.

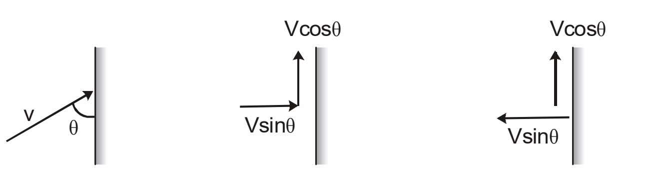
18. Minimum distance between particle A and B during motion will be :
(*a*) ℓ (*b*) h
(*c*) $\sqrt{\ell^2+b^2}$ (*d*) $\ell + h$

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

PROJECTILE

Comprehension-2 (Q. No 20 to 22)

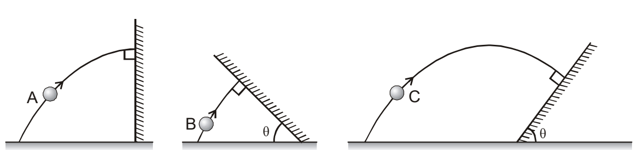
We know how by neglecting the air resistance, the problems of projectile motion can be easily solved and analysed. Now we consider the case of the collision of a ball with a wall. In this case the problem of collision can be simplified by considering the case of elastic collision only. When a ball collides with a wall we can divide its velocity into two components, one perpendicular to the wall and other parallel to the wall. If the collision is elastic then the perpendicular component of velocity of the ball gets reversed with the same magnitude.



Velocity just before collision — Components of velocity just before collision — Components of velocity just after collision

The other parallel component of velocity will remain constant if given wall is smooth.

Now let us take a problem. Three balls ‘A’ and ‘B’ & ‘C’ are projected from ground with same speed at same angle with the horizontal. The balls A,B and C collide with the wall during their flight in air and all three collide perpendicularly with the wall as shown in figure.



20. Which of the following relation about the maximum height H of the three balls from the ground during their motion in air is correct :
(*a*) $H_A = H_C > H_B$ (*b*) $H_A > H_B = H_C$
(*c*) $H_A > H_C > H_B$ (*d*) $H_A = H_B = H_C$

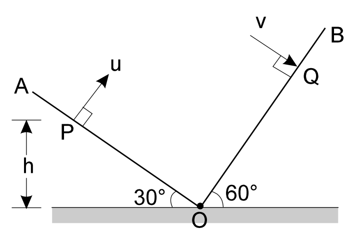
21. If the time taken by the ball A to fall back on ground is 4 seconds and that by ball B is 2 seconds. Then the time taken by the ball C to reach the inclined plane after projection will be :
(*a*) 6 sec. (*b*) 4 sec.
(*c*) 3 sec. (*d*) 5 sec.

22. The maximum height attained by ball ‘A’ from the ground is:
(*a*) 10m
(*b*) 15m
(*c*) 20m
(*d*) Insufficient information

Comprehension-3 (Q. No 23 to 26)

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

(Take $g = 10\ m/s^2$). Then



23. The time of flight is from P to Q is :-
(*a*) 5 Sec.
(*b*) 2 sec.
(*c*) 1 sec.
(*d*) None of these

24. The speed with which the particle strikes the plane OB is:-
(*a*) 10 m/s (*b*) 20 m/s
(*c*) 30 m/s (*d*) 40 m/s

25. The height h of point P from the ground is :-
(*a*) $10\sqrt{3}$ m (*b*) 10m
(*c*) 5m (*d*) 20m

26. The distance PQ is :-
(*a*) 20m (*b*) $10\sqrt{3}$ m
(*c*) 10m (*d*) 5m

CIRCULAR MOTION

Comprehension – 4 (Q. No. 27 to 29)

A particle undergoes uniform circular motion. The velocity and angular velocity of the particle at an instant of time is $\vec{v} = 3\hat{i} + 4\hat{j}$ m/s and $\vec{\omega} = x\hat{i} + 6\hat{j}$ rad/sec.

27. The value of x in rad/s is

(*a*) 8 (*b*) – 8

(*c*) 6 (*d*) can't be calculated

28. The radius of circle in metres is

(*a*) 1/2 m (*b*) 1 m

(*c*) 2m (*d*) can't be calculated

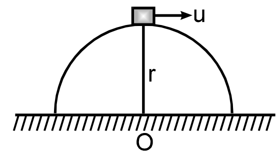
29. The acceleration of particle at the given instant is

(*a*) $-50\hat{k}$ (*b*) $-42\hat{k}$

(*c*) $2\hat{i} + 3\hat{j}$ (*d*) can't be calculated

Comprehension – 5 (Q. No. 30 to 33)

A small block of mass m is projected horizontally from the top of the smooth and fixed hemisphere of radius r with speed u as shown. For values of $u \geq u_0$, ($u_0 = \sqrt{gr}$) it does not slide on the hemisphere. [i.e. leaves the surface at the top itself]



30. For $u = 2u_0$, it lands at point P on ground. Find OP.

(*a*) $\sqrt{2}$ r (*b*) 2r

(*c*) 4r (*d*) $2\sqrt{2}$ r

31. For $u = u_0/3$, find the height from the ground at which it leaves the hemisphere.

(*a*) $\frac{19\,r}{9}$ (*b*) $\frac{19\,r}{27}$

(*c*) $\frac{10r}{9}$ (*d*) $\frac{10r}{27}$

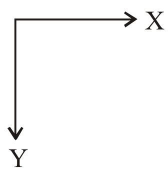
32. Find its net acceleration at the instant it leaves the hemisphere.

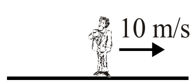
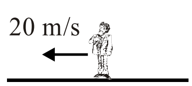
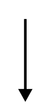
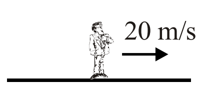
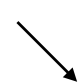
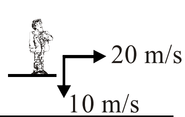
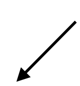
(*a*) g/4 (*b*) g/2

(*c*) g (*d*) g/3

RELATIVE MOTION

33. Rain is falling at velocity $10\hat{i} + 10\hat{j}$ m/s. Then match the direction of velocity of rain w.r.t. man in column-II from column-I.



	Column-I	Column-II
(*a*)		(P) 
(*b*)		(Q) 
(*c*)		(R) 
(*d*)		(S) 
		(T)

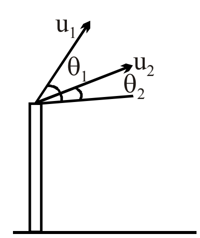
34.

	Column-I	**Column-II**
(*a*)	If swimmer can swim at 5m/sec in still water and if velocity of water flow is 4m/sec then angle between direction of swimming and direction of river flow to minimize drift.	(P) 53°
(*b*)	If swimmer can swim at 5m/sec in still water and velocity of flow is 3m/sec then angle between direction of velocity of swimmer with respect to river and the direction of river flow if swimmer crosses the river in minimum time .	(Q) 127°
(*c*)	If swimmer can swim at 4 m/sec and velocity of flow is 3m/sec then angle of resultant velocity (w.r.t. ground) with the direction of river flow if swimmer swims perpendicular to flow of river.	(R) 143°
(*d*)	Angle between direction of fluttering of flag and north if wind blows towards south west direction with a velocity $3\sqrt{2}$ m/sec. Man moves with a velocity 7m/sec along west, holding flag in his hand.	(S) 90°

35. Column-I shows certain situations with certain conditions and column-II shows the parameters in which situations of Column-I match. Which can be possible combination.

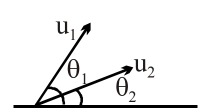
Column-I **Column-II**

(*a*) $u_1 = u_2$; $\theta_1 = \theta_2$ (P)



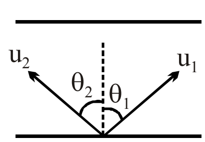
Two projectiles are projected from a height such that they strike ground at the same time.

(*b*) $u_1 > u_2$; $\theta_1 > \theta_2$ (Q)



Two projectiles under standard ground to ground projection such that horizontal range is same.

(*c*) $u_1 < u_2$; $\theta_2 > \theta_1$ (R)



Two swimmer starting from same point on a river bank such that time of crossing is same. u_1 & u_2 are velocities relative to river.

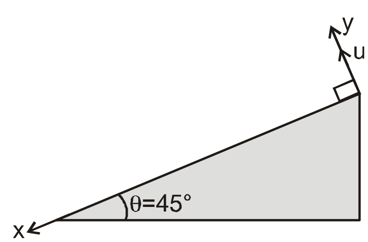
36. Match the following :

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

PROJECTILE

37. An inclined plane makes an angle $\theta = 45°$ with horizontal. A stone is projected normally from the inclined plane, with speed u m/s at t = 0 sec. x and y axis are drawn from point of projection along and normal to inclined plane as shown. The length of incline is sufficient for stone to land on it and neglect air friction. Match the statements given in column I with the results in column II. (g in column II is acceleration due to gravity.)



Column I	Column II
(*a*) The instant of time at which velocity of stone is parallel to x-axis	(p) $\frac{2\sqrt{2}\,u}{g}$
(*b*) The instant of time at which velocity of stone makes an angle $\theta = 45°$ with positive x-axis.	(q) $\frac{2u}{g}$
(*c*) The instant of time till which (starting from t = 0) component of displacement along x-axis become half the range on inclined plane is	(r) $\frac{\sqrt{2}\,u}{g}$
(*d*) Time of flight on inclined plane is	(s) $\frac{u}{\sqrt{2}\,g}$

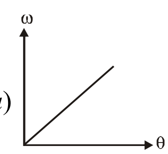
38. A particle is projected from level ground. Assuming projection point as origin, x-axis along horizontal and y-axis along vertically upwards. If particle moves in x-y plane and its path is given by $y = ax - bx^2$ where a, b are positive constants. Then match the physical quantities given in column-I with the values given in column-II. (g in column II is acceleration due to gravity.)

Column I	**Column II**
(*a*) Horizontal component of velocity	(p) $\frac{a}{b}$
(*b*) Time of flight	(q) $\frac{a^2}{4b}$
(*c*) Maximum height	(r) $\sqrt{\frac{g}{2b}}$
(*d*) Horizontal range	(s) $\sqrt{\frac{2a^2}{bg}}$

CIRCULAR MOTION

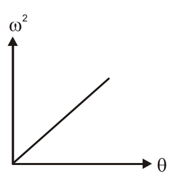
39. Each situation in column I gives graph of a particle moving in circular path. The variables ω, θ and t represent angular speed (at any time t), angular displacement (in time t) and time respectively. Column II gives certain resulting interpretation. Match the graphs in column I with statements in column II.

Column-I **Column-II**

(*a*) 

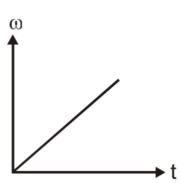
ω - θ graph

(p) Angular acceleration of particle is uniform

(*b*) 

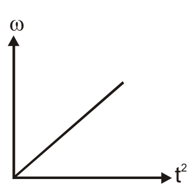
ω² - θ graph

(q) Angular acceleration of particle is non-uniform

(*c*) 

ω - t graph

(r) Angular acceleration of particle is directly proportional to t.

(*d*) 

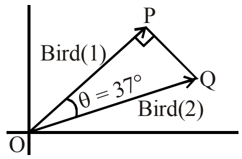
ω - t² graph

(s) Angular acceleration of particle is directly proportional to θ.

NUMERICAL BASED QUESTIONS

Relative Motion

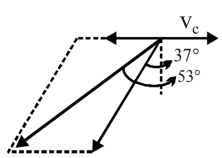
40. Two birds are at origin. They both start to fly in straight lines in different directions making an angle $\theta = 37°$ with each other at the same time as shown.



Bird(1) on reaching a point P takes a right angle turn to reach point Q simultaneously with Bird (2). If the bird(1) was flying with a constant speed of 7 km/hr then what must be the constant speed of bird (2) (in km/hr)?

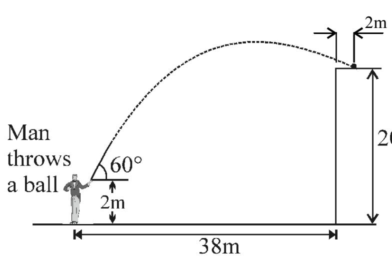
41. Shore based radar indicates that a ferry boat is moving on a river with a speed of 10 m/s at an angle of 30° North of east. The instruments on the ferry boat indicate that it moves with a speed of 10 m/s at an angle of 30° North of west relative to the river. What is the true speed (in m/s) at which river flows? Round off to nearest integer.

42. A car is travelling in steady rain with constant acceleration in a straight line. When it begins to move the driver sees that the raindrops make track at an angle of 37° with the vertical on the side window. After 20 sec., the raindrops make track at an angle of 53° with vertical in same direction. Find the acceleration of the car in cm/s^2. Rain is falling at 3 m/s.



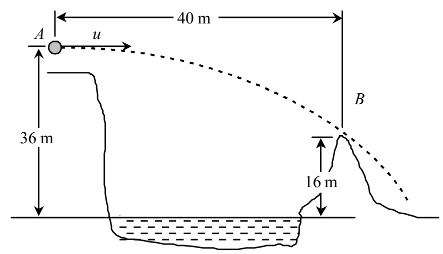
PROJECTILE

43. A soft ball is thrown at an angle of $\alpha = 60°$ above the horizontal. It lands a distance d = 2m from the edge of a flat roof, whose height is h = 20 m ; the edge of the roof is l = 38 m from the thrower (see fig.). At what speed (in m/s) was the softball thrown?



44. When a particle is projected at an angle of 15° from horizontal, it's range is found to be 3.5 m. What would be it's range (in m) if it is projected at an angle of 45° from horizontal with same speed?

45. With what minimum horizontal velocity 'u', (in m/s) can a boy throw a rock at A so that it just clear the obstruction at B

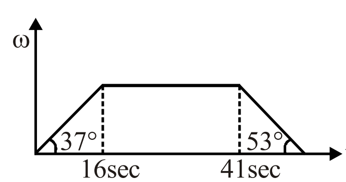


CIRCULAR MOTION

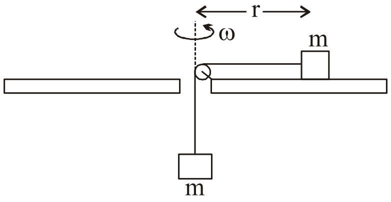
46. An electric drill starts from rest and rotates with constant angular acceleration. After it has rotated through an angle θ, the magnitude of centripetal acceleration of a point on the drill is twice the magnitude of tangential acceleration. What is the angle (in rad.)

47. Find the radius (in cm) of a rotating disc if the velocity of a point on rim is 5 times the velocity of a point located 5 m closer to the centre.

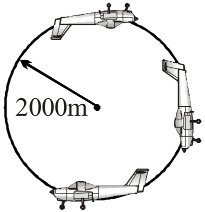
48. The angular velocity of a body moving in a circular path is shown in graph below. What is the average angular velocity (in rad/s) for the entire motion ? Approximate the answer to nearest integer.



49. Two equal masses m are attached by a string. One mass lies at radial distance r from the centre of a horizontal turntable which rotates with constant angular velocity $\omega = 2$ rad s^{-1}, while the second hangs from the string inside the turntable's hollow spindle (see fig.). The coefficient of static friction between the turntable and the mass lying on it $\mu_s = 0.5$. The maximum and minimum values such that the mass lying on the turntable does not slide are r_{max}, r_{min}. Then $(r_{max} + r_{min})$ (in meter).



50. An air craft loops the vertical loop as shown with constant speed. At the top most point, the normal force exerted on the pilot by his seat is $\frac{1}{3}$ times the force exerted by the seat at the lowest point. What is the speed (in m/s) of the plane?



Topicwise Solutions

1. (*b*) Time $= \dfrac{\text{Total length}}{\text{Relative velocity}} = \dfrac{50+50}{10+15} = \dfrac{100}{25} = 4$ sec

2. (*b*) Relative velocity of bird w.r.t train= 25 + 5 = 30 m/s
time taken by the bird to cross the train

$$t = \frac{210}{30} = 7 \text{ sec}$$

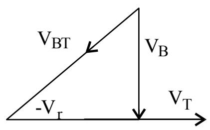
3. (*d*) At t = 3 sec, 1st stone will have speed of 30 m/s

$$h_1 = \frac{1}{2}\times 10\times 9 = 45\text{m}$$

$$h_2 = \frac{1}{2}\times 10\times 1^2 = 5\text{m}$$

$$h_1 - h_2 = 40\text{m}$$

4. (*c*)



$$\vec{V}_{BT} = \vec{V}_B - \vec{V}_T$$

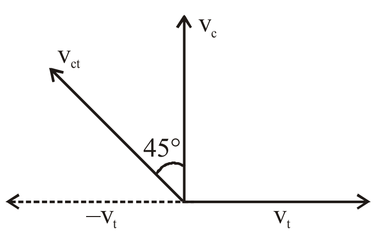
$$V_{BT} = \sqrt{40^2 + 40^2}$$

$$= 40\sqrt{2}$$

Direction $\rightarrow$ SW

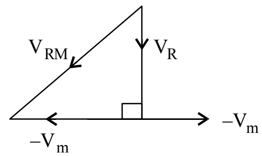
5. (*b*) $\vec{v}_{ct} = \vec{v}_c - \vec{v}_t$

$$\vec{v}_{ct} = \vec{v}_c + (-\vec{v}_t)$$



Velocity of car w.r.t. train (v_{ct}) is towards West – North

6. (*c*)

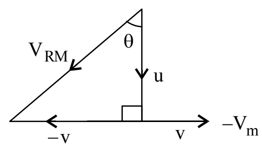


$$\vec{V}_{RM} = \vec{V}_R - \vec{V}_m$$

$$V_{RM} = \sqrt{V_R^2 + V_m^2}$$

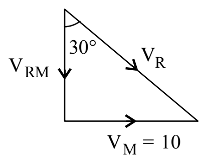
$$= \sqrt{109}$$

7. (*a*)



$$\tan\theta = \frac{v}{u}$$

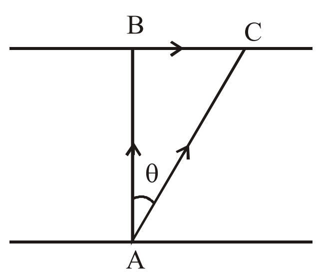
8. (*b*)



$$\tan 30° = \frac{V_m}{V_{RM}} = \frac{10}{V_{RM}}$$

$$V_{RM} = 10\sqrt{3}$$

9. (*c*) Given $\overrightarrow{AB}$ = Velocity of boat = 8 km/hr



$\overrightarrow{AC}$ = Resultant velocity of boat = 10 km/hr

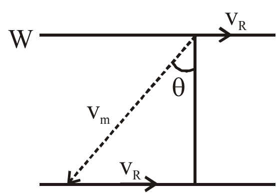
$\overrightarrow{BC}$ = Velocity of river = $\sqrt{AC^2 - AB^2}$

$= \sqrt{(10)^2 - (8)^2} = 6 \text{ km/hr}$

10. (*b*) The relative velocity of boat w.r.t. water

$$= v_{boat} - v_{water} = (3\hat{i} + 4\hat{j}) - (-3\hat{i} - 4\hat{j}) = (6\hat{i} + 8\hat{j})$$

11. (*c*) For shortest possible path man should swim with an angle (90+θ) with downstream.

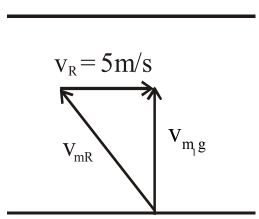


From the fig, $\sin\theta = \dfrac{v_r}{v_m} = \dfrac{5}{10} = \dfrac{1}{2} \Rightarrow \therefore \theta = 30°$

So angle with downstream = 90° + 30° = 120°

12. (*a*) Due north will take himacross in shortest time.

13. (*b*)

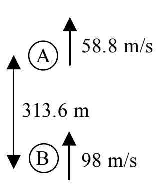


$$\frac{60\text{m}}{5} = \sqrt{v_m^2 - v_2^2}$$

$\Rightarrow\ 144 + 5^2 = v_m^2$

$\Rightarrow\ v_m = 13 \text{ m/s}$

14. (*d*) At t = 4s



$a_{ml} = 0$

$s_{ml} = U_{nl} t$

$t = \dfrac{313.6}{39.2} = 8\text{s}.$

$T = t + 4 = 12\text{s}$

15. (*c*) $v_x = \dfrac{dx}{dt} = 6$ and $v_y = \dfrac{dy}{dt} = 8 - 10t$

$= 8 - 10 \times 0 = 8$

$\therefore\ v = \sqrt{v_x^2 + v_y^2} = \sqrt{6^2 + 8^2} = 10 \text{ ms}^{-1}$

16. (*d*) $R = \dfrac{u^2 \sin 2\theta}{g} \therefore R \propto u^2$. If initial velocity be doubled then range will become four times.

17. (*c*) $H = \dfrac{u^2 \sin^2\theta}{2g} \therefore H \propto u^2$. If initial velocity be doubled

18. (*a*) Direction of velocity is always tangent to the path so at the top of trajectory, it is in horizontal direction and acceleration due to gravity is always in vertically downward direction. It means angle between $\vec{v}$ and $\vec{g}$ are perpendicular to each other.

19. (*b*) $R_{15°} = \dfrac{u^2 \sin(2\times 15°)}{g} = \dfrac{u^2}{2g} = 1.5\ km$

$$R_{45°} = \frac{u^2 \sin(2\times 45°)}{g} = \frac{u^2}{g} = 1.5 \times 2 = 3\,km.$$

20. (*a*) For vertical upward motion $h = ut - \dfrac{1}{2}gt^2$

$$5 = (25 \sin\theta) \times 2 - \frac{1}{2} \times 10 \times (2)^2$$

$$\Rightarrow 25 = 50\sin\theta \Rightarrow \sin\theta = \frac{1}{2} \Rightarrow \theta = 30°.$$

21. (*b*) Range is given by $R = \dfrac{u^2 \sin 2\theta}{g}$

On moon $g_m = \dfrac{g}{6}$. Hence R_m = 6R.

22. (*b*) $y = ut\sin\theta - \dfrac{gt^2}{2}$

$V_r = 0$ (zero shape)

$a_r = -g$ (negative curvature)

23. (*d*) $R = \dfrac{v^2 \sin 2\theta}{g} \Rightarrow \theta = \dfrac{1}{2}\sin^{-1}\left(\dfrac{gR}{v^2}\right).$

24. (*c*) Due to constant velocity along horizontal and vertical downward force of gravity stone will hit the ground following parabolic path.

25. (*d*) $t = \sqrt{\dfrac{2h}{g}} = \sqrt{\dfrac{2\times 396.9}{9.8}} \simeq 9$ sec and u = 720 km/ hr

= 200 m/s

$\therefore$ R = u × t = 200 × 9 = 1800 m

26. (*c*) $T = \dfrac{2u\sin 45°}{g\cos 45°} = 2\,\text{sec}$

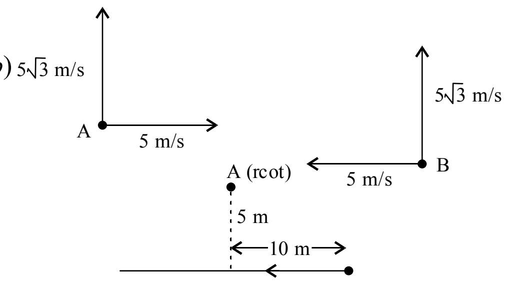
27. (*d*) $PQ = \frac{1}{2} g \sin\theta\, T^2$

$$T = \frac{2v}{g\cos\theta}$$

$$PQ = \frac{1}{2} g \sin\theta \left(\frac{2v}{g\cos\theta}\right) T$$

$$PQ = Tv \tan\theta$$

28. (*b*)



$$t = \frac{10}{10} = /s$$

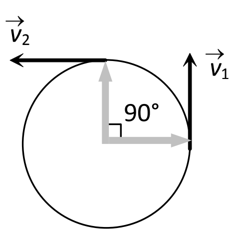
29. (*c*) It is always directed in a direction of tangent to circle.

30. (*a*) In uniform circular motion (constant angular velocity) kinetic energy remains constant but due to change in velocity of particle its momentum varies.

31. (*c*) $\omega_{min} = \frac{2\pi}{60}\frac{Rad}{min}$ and $\omega_{hr} = \frac{2\pi}{12\times 60}\frac{Rad}{min}$

$$\therefore \frac{\omega_{min}}{\omega_{hr}} = \frac{2\pi/60}{2\pi/12\times 60}$$

32. (*d*) In 15 second's hand rotate through 90°.



Change in velocity $\left|\overrightarrow{\Delta v}\right| = 2v\sin(\theta/2)$

$$= 2(r\omega)\sin(90^\circ/2) = 2\times 1\times\frac{2\pi}{T}\times\frac{1}{\sqrt{2}}$$

$$= \frac{4\pi}{60\sqrt{2}} = \frac{\pi\sqrt{2}}{30}\frac{cm}{sec} \text{ [As T = 60 sec]}$$

33. (*b*) $\vec{v} = \vec{\omega}\times\vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -4 & 1 \\ 5 & -6 & 6 \end{vmatrix} = -18\hat{i} - 13\hat{j} + 2\hat{k}$.

34. (*c*) $\omega = 80$ rad/sec, $t = 5$ sec, $\omega_0 = 0$

$\theta = ?$

If α constant, then

$$\theta = \left(\frac{\omega+\omega_0}{2}\right) t = \left(\frac{80+0}{2}\right) 5 = 200 \text{ rad } \textbf{Ans.}$$

35. (*a*) $V = \omega.r \Rightarrow V = 30\times 2\pi\times\frac{1}{2} = 30\pi$

36. (*c*) Direction & megnitude of Angular velocity & angular momentum stays unstant.

37. (*c*) Centripetal acceleration $= \frac{v^2}{r}$ = constant. Direction keeps changing.

38. (*a*) $\frac{a_R}{a_r} = \frac{\omega_R^2\times R}{\omega_r^2\times r} = \frac{T_r^2}{T_R^2}\times\frac{R}{r} = \frac{R}{r}$ [As $T_r = T_R$]

39. (*d*) The particle performing circular motion flies off tangentially.

40. (*a*) $\alpha = 4\pi^2 n^2 r = 4\pi^2\left(\frac{1}{2}\right)^2\times 50 = 493$ cm/s^2.

41. (*c*) Angular velocity of every particle of disc is same

$$a_p = \omega^2 r_p, a_Q = \omega^2 r_Q$$

$$\because r_p > r_Q \Rightarrow a_p > a_Q$$

42. (*a*)

43. (*d*) Centripetal force is constant in magnitude that means speed is constant and due to change in direction velocity is variable.

44. (*b*)

45. (*b*) $F = K\frac{1}{r}\frac{k}{r} = \frac{mv^2}{r} v = \sqrt{\frac{k}{m}}$

so independent to r

46. (*a*) Force is perpendicular to $\vec{v}$

$$R = \frac{v^2}{a_\perp} \Rightarrow R = \frac{mv^2}{F}$$

47. (*c*) $F_{C1} = F_{C2}$

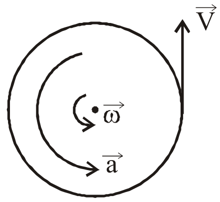
$$\Rightarrow \frac{mv_1^2}{r_1} = \frac{mv_2^2}{r_2}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \frac{1}{\sqrt{2}}$$

48. (*c*) $K = \frac{mV^2}{2}$

49. (*a*) $a_c = wv$

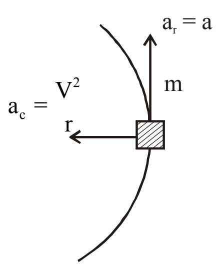
50. (*b*)



51. (*b*) $a_t = \alpha r = \omega^2 r = \alpha^2 t^2 r$

$\alpha \times \frac{1}{t^2}$

52. (*b*) $|\vec{a}| = \sqrt{a_c^2 + a_t^2} = \sqrt{\frac{v^2}{r^2} + a^2}$



53. (*a*) Thrust at the lowest point of concave bridge

$= mg + \frac{mv^2}{r}$

54. (*b*) ν = 72 km / hour = 20 m/sec

$\theta = \tan^{-1}\left(\frac{\nu^2}{rg}\right) = \tan^{-1}\left(\frac{20 \times 20}{20 \times 10}\right) = \tan^{-1}(2)$

55. (*a*) centripetal force $= \frac{mV^2}{r}$

56. (*b*)

57. (*a*) $T = \frac{m\nu^2}{r} \Rightarrow 25 = \frac{0.25 \times \nu^2}{1.96} \Rightarrow \nu = 14$ m/s.

58. (*a*) $\frac{m\nu^2}{r} = \frac{k}{r^2}$

$\Rightarrow m\nu^2 = \frac{k}{r}$; K.E. $= \frac{1}{2}m\nu^2 = \frac{k}{2r}5$

$P.E = \int F\,dr = \int \frac{k}{r^2}dr = -\frac{k}{r}$

$\therefore$ Total energy = K.E. + P.E. $= \frac{k}{2r} - \frac{k}{r} = -\frac{k}{2r}$.

59. (*d*) $F = mg - \frac{m\nu^2}{r}$.

60. (*c*) $\nu_{max} = \sqrt{\mu rg} = \sqrt{0.75 \times 60 \times 9.8} = 21$m/s.

61. (*c*) T = Tension, W = weight and F = centrifugal force.

62. (*b*) $T = \frac{mv^2}{r}$

$= \frac{0.5 \times (4)^2}{1} = 8$N

63. (*d*) p = mv, & F = mv²/r $\Rightarrow F = m\left(\frac{p}{m}\right)^2 / r$

$\Rightarrow \quad F = \frac{p^2}{mr}$

64. (*d*) $\nu_{max} = \sqrt{\mu rg}$

Learning Plus

1. (*b*) Total Length of 2 trains = 50 + 50 = 100

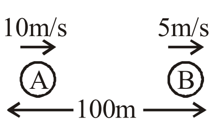
Velocity $V_1 = 10$

$V_2 = 15$

$V_1 + V_2 = 25$

time $= \frac{100}{25} = 4$ sec

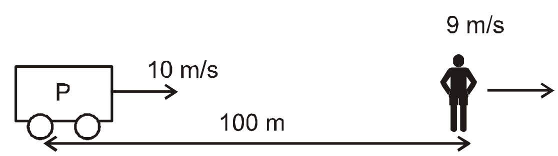
2. (*c*)



$V_{AB} = 10 - 5 = 5$ m/s

$t = \frac{100}{5} = 20$ sec

3. (*d*) $\vec{V}_{PT} = \vec{V}_P - \vec{V}_T = 10 - 9 = 1$ m/s



So time taken $t = \frac{100}{\vec{V}_{PT}} = \frac{100}{1} = 100$ sec.

4. (*d*) $V_{rel} = \frac{S_{rel}}{t} = \frac{1000}{100} = 10$ m/s.

$\therefore \quad V_S - V_B = 10$

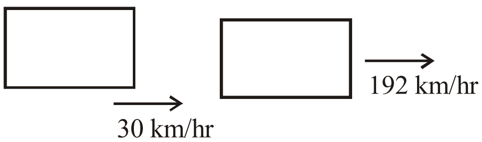
$\Rightarrow \quad V_S = 10 + V_B = 10 + 10 = 20$ m/s. **Ans.**

5. (*b*) We have, $S_{rel} = u_{rel}t + \frac{1}{2}a_{rel}\,t^2$

$\Rightarrow\ 0 = ut - \frac{1}{2}(a + g)\,t^2$

$\Rightarrow\ a = \frac{2u}{t} - g = \frac{2u - gt}{t}$

6. (*a*)



$\frac{25}{3}$ m/s = 30 km/h

Muzzle speed = velocity of bullet w.r.t. revolver
= velocity of bullet w.r.t. van

$150 = V_b - V_v$

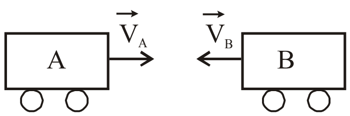
$150 = V_b - \frac{25}{3}\ \Rightarrow\ V_b = \frac{475}{3}$ m/s w.r.t. ground

Now speed with which bullet hit thief's car
= velocity of bullet w.r.t car

$= V_{bc} = V_b - V_c$

$= \frac{475}{3} - \frac{160}{3} = \frac{315}{3} = 105$ m/s

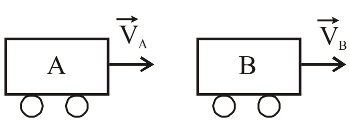
7. (*a*)



In opposite direction

$\vec{V}_{AB} = \vec{V}_A + \vec{V}_B$

$9 = \vec{V}_A + \vec{V}_B$ .... (*a*)



In same direction -

$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$

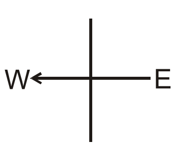
$1 = \vec{V}_A - \vec{V}_B$ .... (*b*)

From equation (*a*) & (*b*)

$\vec{V}_A = 5$ m/s

$\vec{V}_B = 4$ m/s

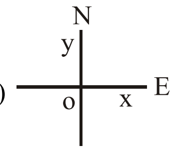
8. (*a*)



$\vec{V}_A = -500\,\hat{i}\qquad \Rightarrow \vec{V}_{GA} + \vec{V}_A = V_{GAS}$

$\vec{V}_{GA} = 1500\,\hat{i}\qquad \Rightarrow 1500\,\hat{i} - 500\,\hat{i} = 1000\,\hat{i}$

9. (*d*)



$\vec{V}_r = 50\,(-\hat{j}) - 50\,\hat{i} = 50\,(-\hat{i} - \hat{j})$ i.e., in south west

10. (*d*) $\vec{V}_{12} = \vec{V}_1 - \vec{V}_2$

$|\vec{V}_{12}| = \sqrt{V_1^2 + V_2^2 - 2V_1V_2\cos\theta}$

If $\cos\theta = -1$

$|\vec{V}_{12}|_{max} = \sqrt{V_1^2 + V_2^2 + 2V_1V_2}$

$|\vec{V}_{12}|_{max} = (V_1 + V_2)$

So $|\vec{V}_{12}|$ is maximum when $\cos\theta = -1$ and $\theta = \pi$

11. (*d*) $\vec{V}_1 = \hat{i} + \sqrt{3}\,\hat{j}$ $\tan\theta_1 = \sqrt{3}$ i.e., $\theta_1 = 60$.

$\vec{V}_2 = 2\hat{i} + 2\,\hat{j}$ $\tan\theta_2 = 1$ i.e., $\theta_2 = 45^o$ $\theta_1 - \theta_2 = 15^o$

12. (*a*) $\vec{V}_r = \upsilon_y\,j$

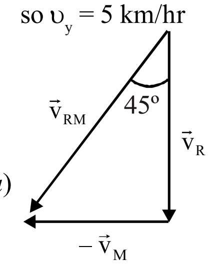
$\vec{\upsilon}_m = 5\hat{i}$

$\vec{V}_r - \vec{V}_m = (-5)\,\hat{i} + \upsilon_y\,\hat{j}$

$\tan\theta = 1 = \frac{\upsilon_y}{5}$

so $\upsilon_y = 5$ km/hr

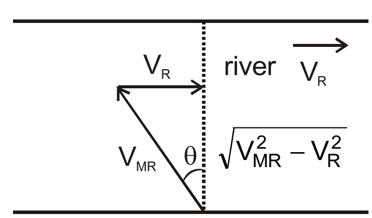
13. (*a*)



$\vec{v}_{RM} = \vec{v}_R - \vec{v}_m$

so $v_R = v_M$

14. (*b*) 15 min = 1/4 hr.



$t = \frac{d}{V_y} \Rightarrow \frac{1}{4} = \frac{1}{\sqrt{V_{MR}^2 - V_R^2}} = \frac{1}{4} = \frac{1}{\sqrt{5^2 - V_R^2}}$

$\Rightarrow V_R = 3$ km/h

15. (*b*) $T_0 = \dfrac{d}{V} + \dfrac{d}{V} = \dfrac{2d}{V}$

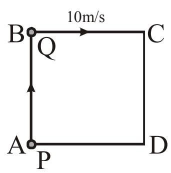
$$T = \frac{d}{V+u} + \frac{d}{V-u} = \frac{2Vd}{V^2 - u^2}$$

$$T = \frac{\frac{V^2 T_0}{V^2 - u^2}}{} = \frac{T_0}{1 - \frac{u^2}{V^2}}$$

$$\frac{T}{T_0} = \frac{1}{1 - \frac{u^2}{V^2}}$$

16. (*c*) Viewing the motion from river frame ; both boats will reach the ball simultaneously

17. (*b*)



a = 8 m

They meet when Q displace 8 × 3 m more than p $\Rightarrow$ relative displacement = relative velocity × time.

8 × 3 = (10 – 2) t   t = 3 sec

18. (*b*) $V_x = 2at$

$V_y = 2bt$

$V = 2t\sqrt{a^2 + b^2}$

19. (*c*) In projectile motion Horizontal accelereation $a_x = o$ & Vertical acceleration $a_y = g = 10 m/s^2$ $a_x = o$

$a_x = 0$

$a_y = 10$ (down)

$\Rightarrow$ only "C" is correct

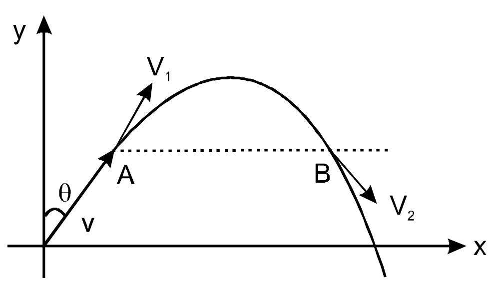
20. (*d*) $\theta_1 = \dfrac{5\pi}{36}$

Another angle for same range is the complementary angle θ_2

Then $\theta_2 = \dfrac{\pi'}{2} - \left(\dfrac{5\pi}{36^o}\right)^c = \dfrac{18-5}{36}\pi \Rightarrow \theta_2 = \dfrac{13}{36}\pi$

"D" **Ans.**

21. (*a*)



Avg. vel. b/w A & B $= \dfrac{\vec{V}_1 + \vec{V}_2}{2}$ ($\because$ Acceleration is constant = g)

Now, if $\vec{V}_1 = V_{1x}\,\hat{i} + V_{1y}\,\hat{j}$

Than $\vec{V}_2 = V_{1x}\,\hat{i} - V_{1y}\,\hat{j}$

($\because$ both A & B are at same lavel)

$\therefore \dfrac{\vec{V}_1 + \vec{V}_2}{2} = V_{1x}\,\hat{i} = V \sin\theta\,\hat{i}$

($\because \theta$ is from vertical) " B "

22. (*a*) Gravitational acceleration is constant near the surface of the earth.

23. (*d*) $R = u^2 \sin 2\theta / g$

$R_{max} = u^2/g$

$$22 = \frac{u^2}{g}$$

for $\theta = 15°$

$$R = \frac{u^2 \sin 30}{g} = 22 \times \frac{1}{2} = 11m$$

24. (*d*) $y = x\tan\theta\left(1 - \dfrac{x}{R}\right)$

$$y = x\tan\theta - \tan\theta\frac{x^2}{R}$$

Compare from eq^n.

$\tan\theta = 16$

$$\frac{\tan\theta}{R} = \frac{5}{4}$$

$$R = \frac{64}{5} = 12.8\,m$$

$\tan\theta = 16$

$$\frac{1}{2}\frac{g}{u^2\cos^2\theta} = \frac{5}{4.2}$$

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{2g}{5} \times \frac{2 \times 16}{g}$$

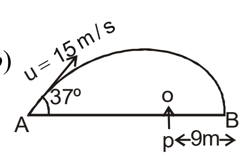
$R = 12.8$ m

25. (*c*) Range of θ and 90-θ is same

If θ = 30°

So 90 - θ = 60°

26. (*b*)



In this process both time taken is same.

$$T = \frac{2u\sin\theta}{g}$$

$$T = \frac{2u\sin 37^\circ}{g}$$

$$= \frac{2 \times 15 \times 3}{10 \times 5} = 1.8\,\text{Sec}$$

Minimum Velocity $= \frac{9}{1.8} = 5\,\text{m/s}$

27. (*b*) $\therefore H_{max} = \frac{u_y^{\,2}}{2g}$

$$\Rightarrow u_y = \sqrt{2gH}$$

$$\therefore T = \frac{2u_y}{g} = \frac{2\sqrt{2gH}}{g} = 2\sqrt{2}\sqrt{\frac{H}{g}}$$

28. (*b*) As $\theta \uparrow$, H and T both increases

But R $\uparrow$ from 0° to 45° & at θ = 45° Max then decreases

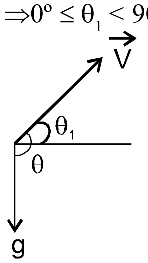
Ans (*b*) R$\uparrow$ then $\downarrow$ [θ from from 30° to 60°]

while H$\uparrow$ and T$\uparrow$.

29. (*d*) Acute Angle of Velocity with horizontal possible is – 90° to + 90° hence angle with g is 0° to 180°.

θ_1 is acute

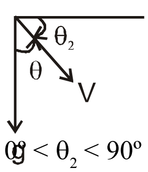
$\Rightarrow 0^\circ \le \theta_1 < 90^\circ$(during the upward journey of mass)



from fig. $\theta = 90^\circ + \theta_1$

or, $90^\circ \le \theta < 180^\circ$ ....(*a*)

During downward motion



$0^\circ < \theta_2 < 90^\circ$

$\theta = 90^\circ - \theta_2$

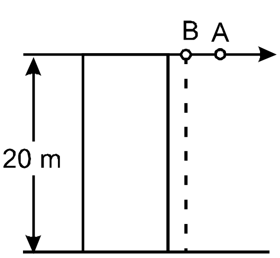
$0^\circ < \theta < 90^\circ$ ....(*b*) From eq.

(*a*) and (*b*)

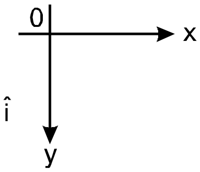
i.e.,$0 < \theta < 90^\circ \cup 90^\circ \le \theta < 180^\circ$

$\Rightarrow 0^\circ < \theta < 180^\circ$ "D"

30. (*d*)



10 m/s = u_A ;



u_B = 0 m/s$u_A = 10\ \hat{i}$

On reaching the ground,

Both will have same vertical velocity

$V_y^{\,2} = u_y^{\,2} + 2a_y s_y$

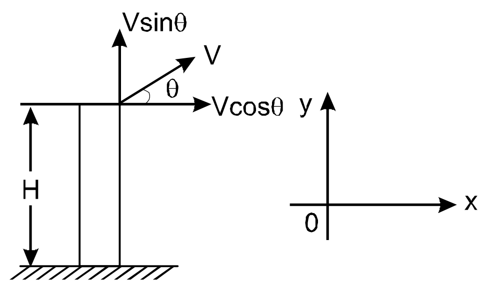
since $u_y = 0$ for both A & B

$a_y = g$ for both A & B

s_y = 20 m for both A & B

Thats why the time taken by both are same

31. (*d*)



Let final vel be V_2

Now v_{2x} = horizontal component of velocity

$V_{2x} = V\cos\theta$ & $V^2_{2y} = (V\sin\theta)^2 + 2(-g)(-H)$

$\therefore V^2_{2y} = V^2\sin^2\theta + 2gH$

$\Rightarrow V^2_2 = V^2_{2x} + V^2_{2y}$

$= (V\cos\theta)^2 + [V^2\sin^2\theta + 2gH]$

$V^2_2 = V^2 + 2gH$

i.e., $V = \sqrt{v^2 + 2gH}$ $\left\{V_2 = \sqrt{V^2 + 2gH}\right\}$

This magnitude of final velocity is independent on θ

$\Rightarrow$ all particles strike the ground with the same speed.

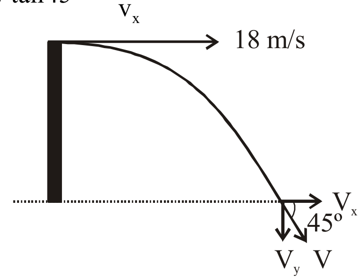
i.e., 'A' is correct.

In vertical motion

The highest velocity (initial) along the direction of displacement is possessed by particle (*a*). Hence particle (*a*) will reach the ground earliest. [since a_y and s_y are same for all]

i.e., 'C' is correct

32. (*b*) $\tan 45^\circ = \frac{v_y}{v_x}$



$\Rightarrow v_y = v_x = 18\text{m/s}$

33. (*d*) $(Y_{max}) \Rightarrow \dfrac{dY}{dt} = 0$

$\Rightarrow \dfrac{d}{dt}(10\,t - t^2) = 10 - 2\,t \Rightarrow t = 5$

$\Rightarrow Y_{max} = 10(5) - 5^2 = 25$ m **Ans** "D"

34. (*d*) (i) For θ and 90-θ

Range is same

$\theta = 15^0$

$90\text{-}\theta = 75^0$

(ii) $R = \dfrac{u\sin\theta . u\cos\theta}{g}$

$\therefore$ sin (90 - θ) = cos θ

$\therefore$ cos (90 - θ) = sin θ

35. (*b*) Vel. of Bomb is same as the vel. of aeroplane.

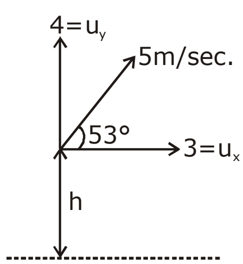
$u_x = 360$ km/h & $v_y = 0$.

$S_y = u_y t + \dfrac{1}{2} a_y t^2$, Here u = 0

$1960 = \dfrac{1}{2} \times 9.8 t^2$

t = 20 sec

36. (*c*) $v_y{}^2 - u_y{}^2 = 2\,a_y S$



$v_y{}^2 - (4)^2 = -2 \times 10 \times 0.45$

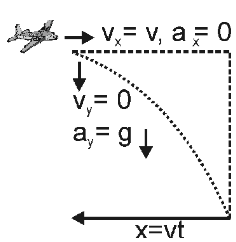
$v_y{}^2 = 7 m^2/s^2$

$v_x = 5\cos 53^o = 3$ m/s(always remains same)

$\therefore V_{net} = \sqrt{(V_x)^2 + (V_y)^2} = \sqrt{9+7}$

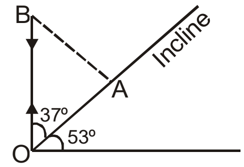
= 4m / s

37. (*a*)



Because horizontal velocity of plane and bomb is always same.

38. (*a*) $OB = \dfrac{u^2}{2g} = 5m$



$\therefore$ AB = OB sin37° = 3m.

39. (*b*) At maximum height v = u cosθ

$\dfrac{u}{2} = v \Rightarrow \dfrac{u}{2} = u\cos\theta$

$\Rightarrow \cos\theta = \dfrac{1}{2} \qquad \Rightarrow \theta = 60°$

$R = \dfrac{u^2 \sin 2\theta}{g} = \dfrac{u^2\sin(120°)}{g}$

$= \dfrac{u^2\cos 30°}{g} = \dfrac{\sqrt{3}\,u^2}{2g}$

40. (*c*) Speed $\qquad v_1 = \dfrac{2\pi r}{t}$

$v_2 = \dfrac{2\pi r}{t}$

$\omega_1 = \dfrac{v_1}{r} = \dfrac{2\pi}{t} \Rightarrow \omega_2 = \dfrac{v_2}{2r} = \dfrac{2\pi}{t}$

$\omega_1 = \omega_2 \Rightarrow \dfrac{\omega_1}{\omega_2} = \dfrac{1}{1}$

41. (*d*) $\omega_{second} = \dfrac{2\pi}{T} = \dfrac{2\pi}{60}$ rad/sec.

$v = \omega.r = \dfrac{2\pi}{60} \times 0.06$ m/s $= 2\pi$ mm/s

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i = \sqrt{2}\,v = 2\sqrt{2}\,\pi$ mm/s

42. (*c*) Given, $\omega_0 = 0$, t = 2 sec.

θ = 0, next 2 sec., $\theta = O_2$

$\theta_1 = \dfrac{1}{2}\alpha t^2 = \dfrac{1}{2}\alpha 2^2 = 2\alpha$

$\theta_2 = \dfrac{1}{2}\alpha(2+2)^2 - \dfrac{1}{2}\alpha 2^2 = 6\alpha$

$\dfrac{\theta_2}{\theta_1} = \dfrac{6\alpha}{2\alpha} = 3$

43. (*c*) $\omega_1 = \dfrac{2\pi}{T_1}, \quad \omega_2 = \dfrac{2\pi}{T_2}$

$\omega_1 : \omega_2 = T_2 : T_1$

$T_1 = 12 \times 60 \times 60$ sec.

$T_2 = 60$ sec.
$\omega_1 : \omega_2 = 60 : (12 \times 60 \times 60)$
$\omega_1 : \omega_2 = 1 : 720$

44. (*d*) Given

$a = 10\text{m/sec}^2 \Rightarrow \alpha = 5\,\text{rad/sec}^2$

$a = \alpha\, r$

$r = \frac{10}{5} = 2$ m

45. (*b*) $a_c = \omega^2 R = \frac{4\pi^2}{T^2} R = \frac{4 \times 3.14^2 \times 6400 \times 10^5}{(24 \times 60 \times 60)^2}$

$\omega^2 R = \frac{4\pi^2}{T^2} R = \frac{4 \times 3.14^2 \times 6400 \times 10^5}{(24 \times 60 \times 60)^2} = 3.4\text{cm/sec}^2$

46. (*c*) Given r = 25 cm, n = 2

$\omega = 2\pi \times 2\,\text{rad/s} \Rightarrow a_c = \omega^2 r$

$= (4\pi)^2 \times 0.25 = 16\pi^2 \times 0.25 = 4\pi^2$

47. (*c*) Given

$\omega = \theta^2 + 2\theta$

$\frac{d\omega}{d\theta} = 2\theta + 2 \Rightarrow \left.\frac{d\omega}{d\theta}\right|_{t=1} = 2\theta + 2 = 4$

$\alpha = \frac{\omega d\omega}{d\theta} = (\theta^2 + 2\theta).(2\theta + 2) = 12\ \text{rad/sec}^2$

48. (*d*) r = 144 m, m = 16 kg, $T_{max} = 16$ N

$T = \frac{mv^2}{r}$

$v = \sqrt{\frac{Tr}{M}} = \sqrt{\frac{16 \times 144}{16}} = 12$ m/s

49. (*d*) $T = m\omega^2 r$

$\Rightarrow T^1 = 2T = m\omega_1^2\, r$

$\omega_1 = \sqrt{2}\ \omega = \sqrt{2} \times 5 = \sqrt{50} \sim 7$ rev/min

50. (*c*) For just slip $\Rightarrow \mu mg = m\omega^2 r$
here ω is double then radius is 1/4th
$r' = 4$ cm

51. (*c*) At t = 0,
$a_\perp = g\cos\theta$,

$R = \frac{v^2}{a_\perp} = \frac{u^2}{g\cos\theta}$

52. (*d*) For circular motion in vertical plane normal reaction is minimum at highest point and it is zero, minimum speed of motorbike is -

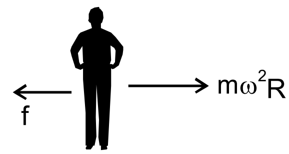
$mg = \frac{mv^2}{R} \Rightarrow v = \sqrt{gR}$

53. (*a*) $T - mg = \frac{mv^2}{r}$ (centripetal force at lowest point)

$T = \frac{mv^2}{r} + mg$

54. (*c*) Car will not slip when moving with speed v

55. (*a*)



$\mu mg \geq \frac{mv^2}{R}$

$0.5\text{ mg} \geq m \times (5)^2 \times R$

$\frac{0.5 \times 10}{25} \geq R$

$R \leq 0.2$ m

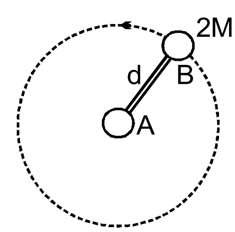
56. (*c*) $v = \sqrt{Rg\tan\theta}$

$R = 10\sqrt{3}$ m, $\theta = 30°$

$= \sqrt{10\sqrt{3} \times 10 \times \frac{1}{\sqrt{3}}} = 10$ m/sec = 36 km/hr

57. (*b*) Here required centripetal force is provided by friction force. Due to lack of sufficient centripetal force car thrown out of the road in taking a turn.

58. (*b*) Given



$P = \frac{2\pi}{\omega} \Rightarrow \omega^{-1} = \frac{P}{2\pi}$

$T = 2M\,\omega^2 d = \frac{8\pi^2 Md}{P^2}$

59. (*a*) The maximum bearable Tension

$T = \frac{mv^2}{l}$

$T_{max} = 10$ N, m = 1, v = ?, l = 1

$\upsilon = \sqrt{\frac{Tl}{m}} = \sqrt{\frac{100 \times 1}{1}} = 10$ m/s

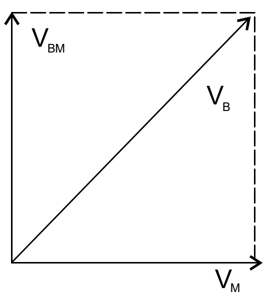
60. (*c*) Given that
v = 72 km/h., r = 80 m
We know that

$\tan\theta = \frac{v^2}{rg} = \frac{20 \times 20}{80 \times 10} = \frac{1}{2}$

$\theta = \tan^{-1}\left(\frac{1}{2}\right)$

Advanced Level Multiconcept Questions

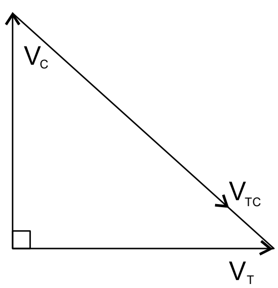
1. (*c*, *d*)



Ball will be catched by man if the cart is unaccelerated. If there is some positive accelerations, then ball will fall behind.

2. (*a*, *b*) 

$|V_T - V_C| = 7$

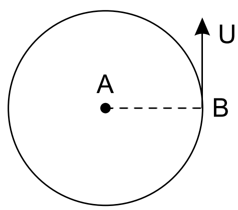


$V_T^2 + V_C = 13^2$

If $V_T = 12, V_C = 5$

If $V_T = 5, \quad V_C = 12$

3. (*a*, *b*, *d*)



Particles are neither approaching nor separating.
But, Relative velocity is V.

$\overrightarrow{V_1} = \overrightarrow{V_B} - \overrightarrow{V_A}$ ....(1)

$\overrightarrow{V_2} = \overrightarrow{V_C} - \overrightarrow{V_B}$ ....(2)

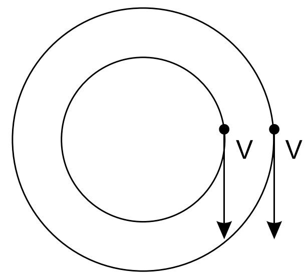
$\overrightarrow{V_0} = \overrightarrow{V_A}$ ....(3)

Adding (1) (2) & (3),

$\overrightarrow{V_c} = \overrightarrow{V_1} + \overrightarrow{V_2} + \overrightarrow{V_0}$

V_C can be zero if $\overrightarrow{V_c} = \overrightarrow{V_1} + \overrightarrow{V_2} + \overrightarrow{V_0} = 0$

Rate of seperation of dog 1 w.r.t. dog 3 = 2V
Rate of seperation of dog 2 w.r.t. dog 4 = 2V



At this instant $V_{rel} = 0$
They would continue to move w.r.t each other,

4. (*b*,*c*,*d*)

V = U + at

-4 = 2 + a + 4

$a = \frac{-3}{2}$ m/s^2

$S_G = V_G t + \frac{a_G t^2}{2}$

$0 = 2t - \frac{3}{4}t^2$

$t = \frac{8}{2} = 2.66$s

Hence, option (D)
In 4S,
SG= 2x

$S_G = 2 \times 4 \frac{-3}{4} \times 4^2$

$= -4$m

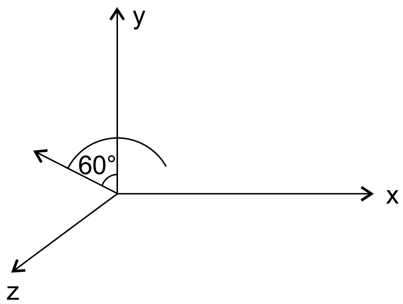
$\therefore$ optin (B)
Wrt Belt

$S_B = U_B t + \frac{1}{2} a_B t^2$

$= 6 \times 4 - \frac{3}{4} \times 4^2$

= 12m

5. (*a*, *d*)



$\vec{V_R} = 2t$ (River)

$\vec{V}_{Boat} = 3t + 2t = 5t$

At $t = 0, \vec{V}_{Ball} = 5t + 5j + 5\sqrt{3}\,k$

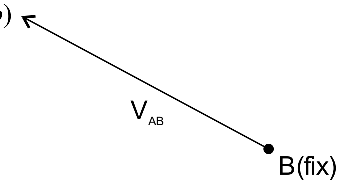
At

Highest Point, $\vec{V}_{Ball} = 5t + 5j$

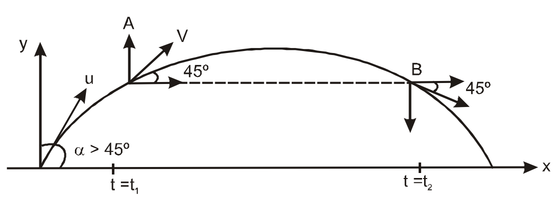
$\vec{V}_{Ball,}$ man $= 5t$

$\left|\vec{V}_{Ball,}\right| = 5\sqrt{2}$

6. (*a*,*b*)



7. (*b*,*d*)
8. (*b*,*c*)



$\Rightarrow$ Time at which $V_x = V_y$ is what we are solving $V_x = V_y$

Now, $V_x = u \cos\alpha$

$V_y = u \sin\alpha - gt$

$\Rightarrow$ $u \cos\alpha = u \sin\alpha - gt$ $\{\because V_y = V_x\}$; at $t = t_1$ (say)

$\Rightarrow$ $t_1 = \dfrac{u}{g}$ $(\sin\alpha - \cos\alpha)$ **"C"**

Also when $V_y \equiv V_x$ {i.e., when we choose 'y' axis as – y'}

at $t = t_2$ (say)

$-u \cos\alpha = u \sin\alpha - gt_2$

$\Rightarrow$ $t_2 = \dfrac{u}{g}$ $(\sin\alpha + \cos\alpha)$ **"B"**

9. (*a*,*b*) $x = 24 = u \cos\theta.t$

$\Rightarrow$ $t = \dfrac{24}{24\cos\theta} = \dfrac{1}{\cos\theta}$

$y = 14 = u \sin\theta t - \dfrac{1}{2}gt^2$

$\Rightarrow$ $14 = \dfrac{u\sin\theta}{\cos\theta} - \dfrac{5}{\cos^2\theta}$

$\Rightarrow$ $14 = u \tan\theta - 5 \sec^2\theta$

$\Rightarrow$ $5 \tan^2\theta - 24 \tan\theta + 19 = 0$

$\Rightarrow$ $\tan\theta = 1, 19/5.$

10. (*a*,*b*,*c*,*d*) $h = \dfrac{u^2}{2g} \Rightarrow u = \sqrt{2gh}$

(a) $R_{max} = \dfrac{u^2}{g} = 2h$

(b) $R = nH_{max}$

$\dfrac{u^2 \sin 2\theta}{g} = n\dfrac{u^2 \sin^2\theta}{2g}$

$4 = n \tan\theta$

$\theta = \tan^{-1}\left(\dfrac{4}{n}\right)$

(*c*) $gT^2 = g \times \dfrac{4u^2 \sin^2\theta}{g^2} = \dfrac{2 \times u^2 \sin 20}{g} \times \tan\theta$

$gT^2 = 2\,R \tan\theta$

(*d*) $T = \dfrac{2u_y}{g}, H_{max} = \dfrac{u_y^{\,2}}{2g}$

$\therefore$ Ratio 1:1

11. (*a*,*c*,*d*) $T = \sqrt{\dfrac{2H}{g}} \Rightarrow 0.4 = \sqrt{\dfrac{2H}{g}}$

$\Rightarrow H = 0.8\text{m}$

$R = 0.4 \times 4 = 1.6\text{m}$

and $U_y = \sqrt{2gH} = \sqrt{2 \times 10 \times 0.8} = 4\text{m/s} \Rightarrow \theta = 45°$

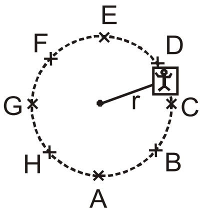
12. (*b*,*d*) (*b*) There are other forces on the particle
(*d*) The resultant of the other forces varies in magnitude as well as in direction.

13. (*a*,*c*,*d*) In curved path, may be circular or parabolic.
In circular path speed and magnitude of acceleration are constant.
In parabolic path acceleration is constant.

14. (*b*,*c*,*d*,*e*) $v = \sqrt{gr}$ $\Rightarrow$ At A

$N = mg + \dfrac{mv^2}{r} = 2mg$ $[v = \sqrt{gr}]$

at E



$$N + \frac{mv^2}{r} = mg$$

$\Rightarrow$ N = 0 $\Rightarrow$ At G and C

N = mg

15. (*b,c*) $T - mg\cos\theta = \frac{mv^2}{L}$

Tangential Acceleration = g sin θ

16. (*b,d*) When speed of car is 36 km/hr, car can make a turn without skidding. If speed is less than 36 km/hr than tendency of slipping is downward so it will slip down. If speed is greater than 36 km/hr than tendency of slipping upward so it will slip up.

If the car's turn at correct speed 36 km/hr

$N\cos\theta = mg$

$$N\sin\theta = \frac{mv^2}{r}$$

$$N = \sqrt{(mg)^2 + \left(\frac{mv^2}{r}\right)}$$

17. (*b*) **18.** (*b*)

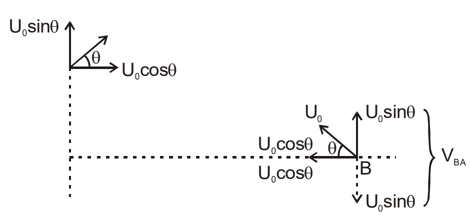
Sol. (17 & 18)

The path of a projectile as observed by other projec tile is a straight line.

$V_A = u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j}$. $V_{AB} = (2u\cos\theta)\,\hat{i}$

$V_B = -u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j}$.

$a_{BA} = g - g = 0$



The vertical component $u_0\sin\theta$ will get cancelled. The relative velocity will only be horizontal which is equal to $2u_0\cos\theta$.

Hence B will travel horizontally towards left w.r.t. A with constant speed $2u_0\cos\theta$ and minimum distance will be h.

19. (*c*) Time to attain this separation will obviously be

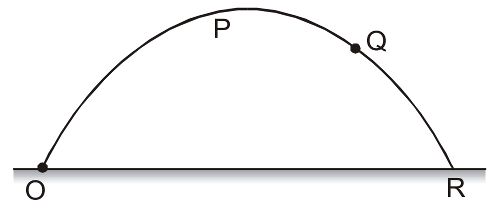
$$\frac{S_{rel}}{V_{rel}} = \frac{\ell}{2u_0\cos\theta}.$$

20. (*a*) $H_A = H_C > H_B$

Obviously A just reaches its maximum height and C has crossed its maximum height which is equal to A as u and θ are same. But B is unable to reach its max. height.

21. (*c*) Time of flight of A is 4 seconds which is same as the time of flight if wall was not there.

Time taken by C to reach the inclined roof is 1 sec.



$T_{OR} = 4$

$T_{QR} = 1$

$\therefore\ T_{OQ} = T_{OR} - T_{QR} = 3$ seconds

22. (*c*) from above $= \frac{2u\sin\theta}{g} = 4$

$\therefore\ u\sin\theta = 20$ m/s $\Rightarrow$ vertical component is 20 m/s.

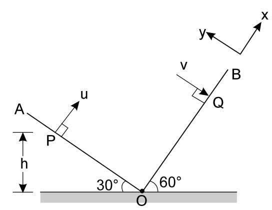
for maximum height

$v^2 = u^2 + 2as \quad \Rightarrow\ 0^2 = 20^2 - 2 \times 10 \times s$

s = 20 m.

23. (*b*) Let us choose the x and y directions along OB and OA respectively. Then

$u_x = u = 10\sqrt{3}$ m/s, $u_y = 0$



$a_x = -g\sin 60° = -5\sqrt{3}$ m/s²

and $a_y = -g\cos 60° = -5$ m/s²

At point Q, x-component of velocity is zero. Hence, substituting in

$v_x = u_x + a_x t$

$0 = 10\sqrt{3} - 5\sqrt{3}t$

or $t = \frac{10\sqrt{3}}{5\sqrt{3}} = 2$s

24. (*a*) At point Q, $v = v_y = u_y + a_y t$

$\therefore\ v = 0 - (5)(b) = -10$ m/s

Here, negative sign implies that velocity of particle at Q is along negative y direction.

25. (*c*)

Distance PO = |displacement of particle along y-direction |

Here, $s_y = u_y t + \frac{1}{2}a_y t^2$

$= 0 - \frac{1}{2}(5)(b)^2 = -10$ m

$\therefore$ PO = 10 m

Therefore, $h = PO \sin 30° = (10)\left(\frac{1}{2}\right)$

or $h = 5$ m

26. (*a*) Distance OQ = displacement of particle along x-direction = s_x

Here $s_x = u_x t + \frac{1}{2} a_x t^2$

$= (10\sqrt{3})(b) - \frac{1}{2}(5\sqrt{3})(b)^2 = 10\sqrt{3}$ m

or $OQ = 10\sqrt{3}$ m

$\therefore \quad PQ = \sqrt{(PO)^2 + (OQ)^2}$

$= \sqrt{(10)^2 + (10\sqrt{3})^2} = \sqrt{100+300} = \sqrt{400}$

$\therefore \quad PQ = 20$ m

27. (*b*) **28.** (*a*) **29.** (*a*)

Sol. (30 to 32)

The angular velocity and linear velocity are mutually perpendicular

$\therefore \ \vec{v}\cdot\vec{\omega} = 3x + 24 = 0$ or $x = -8$

The radius of circle $r = \frac{v}{\omega} = \frac{5}{10} = \frac{1}{2}$ meter

The acceleration of particle undergoing uniform circular motion is

$\vec{a} = \vec{\omega}\times\vec{v} = (-8\hat{i}+6\hat{j})\times(3\hat{i}+4\hat{j})$

$= -50\hat{k}$

$\therefore \ \vec{v}\cdot\vec{\omega} = 3x + 24 = 0$ or $x = -8$

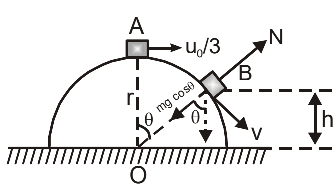
30. (*d*) $mg = \frac{mu_0^2}{r} \Rightarrow u_0 = \sqrt{gr}$

Now, along vertical

$r = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2r}{g}}$

Along horizontal; $OP = 2u_0 t = 2\sqrt{2}\, r$

31. (*b*) As at B it leaves the hemisphere,



$\therefore \ N = 0$

$mg\cos\theta = \frac{mV^2}{r}$

$mg\frac{h}{r} = \frac{mV^2}{r}$

$mv^2 = mgh$ ....(*a*)

By energy conservation between A and B

$mgr + \frac{1}{2}m\left(\frac{u_0}{3}\right)^2 = mgh + \frac{1}{2}mv^2$

Put u_0 and $mv^2 \therefore h = \frac{19r}{27}$

32. (*c*) As $\quad a_c = \frac{v^2}{r} = g\cos\theta$

$\therefore \ a_t = g\sin\theta$

$\therefore \ a_{net} = g$

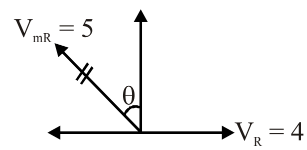
Alternate Solution:

when block leave only the force left is mg.

$\therefore \ a_{net} = g$.

33. (*a*) Q (*b*) R (*c*) S (*d*) T

34. (*a*) -R; (*b*)-S ; (*c*)-P ; (*d*)-Q

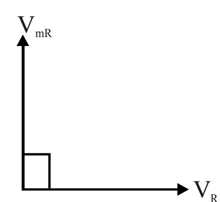


(*a*) $V_{mR}\sin\theta = V_R$

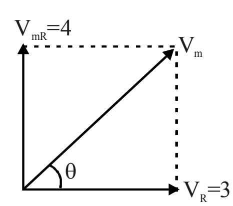
$\Rightarrow \sin\theta = \frac{4}{5} \qquad \Rightarrow \theta = 53°$

$\Rightarrow \theta + 90 = 143°$

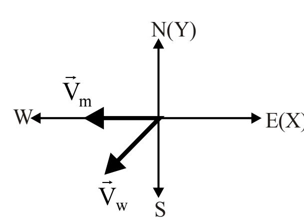
(*b*) Direction of velocity with the direction of flow = 90°

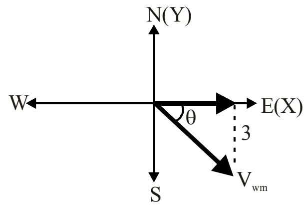


(*c*) $\tan\theta = \frac{4}{3} \quad \Rightarrow \quad \theta = 53°$



(*d*) $\vec{V}_w = -3\hat{i} - 3\hat{j} \Rightarrow \quad \vec{V}_m = -7\hat{i}$





$$\vec{V}_{wm} = \vec{V}_w - \vec{V}_m$$

$$= -3\hat{i} - 3\hat{j} + 7\hat{i} = 4\hat{i} - 3\hat{j}$$

$\tan\theta = \dfrac{3}{4} \Rightarrow \theta = 37° \Rightarrow \theta + 90 = 127°$

35. (*a*) P,Q,R (*b*) Q, R, S (*c*) Q,R,S

36. (*a*)q,(*b*)q,(*c*)q,(*d*)q

In all cases, angle between velocity and net force (in the frame of observer) is in between 0° and 180° (excluding both values, in that path is straight line).

37. (*a*)r (*b*)s (*c*)q (*d*)p Time of flight

$$T = \frac{2u}{g\cos 45°} = \frac{2u}{g\cos 45°} = \frac{2\sqrt{2}u}{g} \quad \therefore D \to p$$

Velocity of stone is parallel to x-axis at half the time of flight.

$$\therefore A \to r$$

At the instant stone make 45° angle with x-axis its velocity is horizontal.

$$\therefore \text{ The time is } = \frac{u\sin 45°}{g} = \frac{u}{\sqrt{2}\,g} \quad \therefore B \to s$$

The time till its displacement along x-axis is half the range is

$$= \frac{1}{\sqrt{2}}T = \frac{2u}{g} \quad \therefore C \to q$$

38. (*a*)r,(*b*)s,(*c*)q,(*d*)p Equation of path is given as

$y = ax - bx^2$

Comparing it with standard equation of projectile;

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

$$\tan\theta = a,\ \frac{g}{2u^2\cos^2\theta} = b$$

Horizontal component of velocity $= u\cos\theta = \sqrt{\dfrac{g}{2b}}$

Time of flight $T = \dfrac{2u\sin\theta}{g} = \dfrac{2(u\cos\theta)\tan\theta}{g}$

$$= \frac{2\left(\sqrt{\frac{g}{2b}}\right)a}{g} = \sqrt{\frac{2a^2}{bg}}$$

Maximum height $H = \dfrac{u^2\sin^2\theta}{2g} = \dfrac{[u\cos\theta.\tan\theta]^2}{2g}$

$$= \frac{\left[\sqrt{\frac{g}{2b}}.\right]^2}{2g} = \frac{a^2}{4b}$$

Horizontal range $R = \dfrac{u^2\sin 2\theta}{2g} = \dfrac{2(u\sin\theta)(u\cos\theta)}{g}$

$$= \frac{2\left[\sqrt{\frac{g}{2b}}.a\right]\left[\sqrt{\frac{g}{2b}}\right]}{g} = \frac{a}{b}$$

39. (*a*)q,s,(*b*)p(*c*)p,(*d*)q,r

From graph (a) $\Rightarrow \omega = k\theta$

where k is positive constant

angular acceleration $= \omega\dfrac{d\omega}{d\theta} = k\theta \times k = k^2\theta$

$\therefore$ angular acceleration is non uniform and directly proportional to θ.

$\therefore$ (*a*) q, s

From graph (b) $\Rightarrow \omega^2 = k\theta$.

Differentiating both sides with respect to θ.

$$2\omega\frac{d\omega}{d\theta} = k \quad \text{or} \quad \omega\frac{d\omega}{d\theta} = \frac{k}{2}$$

Hence angular acceleration is uniform.

$\therefore$ (*b*) p

From graph (c) $\Rightarrow \omega = kt$

angular acceleration $= \dfrac{d\omega}{dt} = k$

Hence angular acceleration is uniform

$\Rightarrow$ (*c*) p

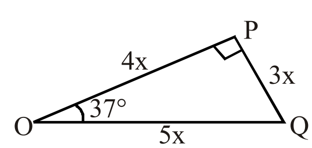
From graph (d) $\Rightarrow \omega = kt^2$

angular acceleration $= \dfrac{d\omega}{dt} = 2kt$

Hence angular acceleration is non uniform and directly proportional to t.

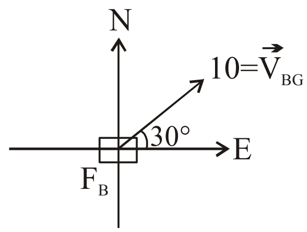
$\therefore$ (*d*) q,r.

40. [0005] Bird (*a*) travels 7x and Bird (*b*) travels 5x in same time,

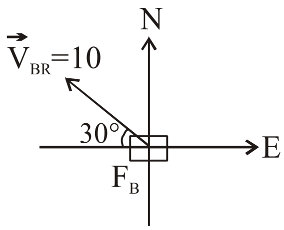


so $\dfrac{v_2}{v_1} = \dfrac{s_2}{s_1} = \dfrac{5x}{7x}$ or $v_2 = \dfrac{5}{7}(v_1) = 5$ km/hr

41. [0017] Ground frame:



River frame :



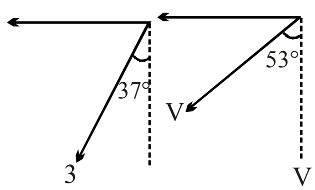
$$\vec{V}_{BG} = \vec{V}_{BR} + \vec{V}_{RG}$$

$$\Rightarrow\ 5\sqrt{3}\,\hat{i} + 5\hat{j} = -5\sqrt{3}\,\hat{i} + 5\hat{j} + \vec{V}_{RG}$$

$$\therefore\ \vec{V}_{RG} = 10\sqrt{3}\,\hat{i}$$

$\therefore\ V_{RG} = 17.3$ m/s

42. [0007]



$$\frac{3V}{5} = \frac{12}{5}$$

$V = 4$

$$\frac{4V}{5} = \frac{9}{5} + V_C = \frac{7}{5}$$

$V_C = 0 + a_C t$

$a_C = 7$

43. [0025] $y = x\tan\theta - \dfrac{1}{2}g\dfrac{x^2}{v^2\cos^2\theta}$

$x = 38 + 2 = 40$

$y = 18$

$\theta = 60°$ $\Rightarrow v = 25$ m/s

44. [0007] $R = \dfrac{u^2\sin(2\theta)}{g}$ $\therefore$ $R \propto \sin(2\theta)$ (for same speed of projection)

$$\therefore\ \frac{R'}{R} = \frac{\sin(2\times45°)}{\sin(2\times15°)}$$

$$\therefore\ R' = 3.5\times\frac{1}{0.5} = 7\text{ m}$$

45. [0020] $-20 = 40\tan 0 - \dfrac{1}{2}\dfrac{g\times40^2}{u^2\cos^2 0°}$

$$u^2 = \frac{1600}{4} = 400$$

$u = 20$ m/s

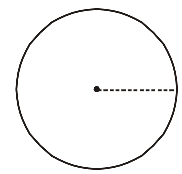
46. [0001] $\omega^2 R = 2R\alpha$

$\omega^2 = 2\alpha = 2\alpha\theta$

$\theta = 1$ rad.

47. [0625] $v = wR$

$$v' = w(R-5) = \frac{\omega R}{5}$$

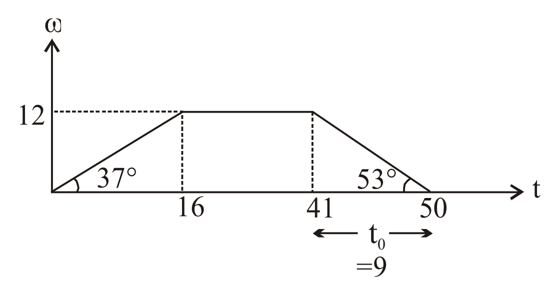


$5R - 25 = R$

$$R = \frac{25}{4}\text{ m} = 6.25\text{ m}$$

48. [0009] $<\omega> = \dfrac{\int \omega\,dt}{\int dt} = \dfrac{\text{Area under graph}}{\text{time}}$

$$= \frac{\frac{1}{2}\times12[25+50]}{50} = 9\text{ r/s.}$$



49. [0005] $T = mg$

$m_{r\max}\,\omega^2 = T + \mu mg$

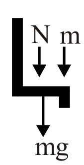
$mr_{\min}\,\omega^2 = T - \mu mg$

$m(r_{\max} + r_{\min})\omega^2 = 2mg$

$$\therefore\ r_{\max} + r_{\min} = \frac{2g}{\omega^2} = 5\text{ m}$$

50. [0200]

$$N_b - mg = \frac{mv^2}{R}$$



$$N_b = mg + \frac{mv^2}{R}$$

$$N_T + mg = \frac{mv^2}{R}$$

$$N_T = \frac{mv^2}{R} - mg = \frac{1}{3}\left(mg + \frac{mv^2}{R}\right)$$

$$\frac{2}{3}\frac{mv^2}{R} = \frac{4}{3}mg$$

$$v = \sqrt{2gR} = \sqrt{20 \times 2000} = 200 \text{ m/s}$$