PHYSICS

BOOKS - CENGAGE PHYSICS (ENGLISH)

KINEMATICS-2

Illustration

1. A projectile is fired with a speed u at an angle θ with the horizontal. Find its speed when its direction of motion makes an angle α with the horizontal.

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2. Which of the path (I) or (II) of a projectile has more time of flight ? Use necessary assumptions.

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3. A grasshopper can jump upto a height h Find the maximum distance through which it can jump along the horizontal ground.

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4. The range of a projectile at an angle θ is equal to half of the maximum range if thrown at the same speed. The angel of projection θ is given by

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5. A batsman deflects a ball by an angle of 45° without changing its initial speed which is equal to $54k\frac{m}{h}$. What is the impulse imparted to the ball ? (Mass of the ball is 0.15 kg)

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6. The horizontal range of a projectile is $2\sqrt{3}$ times its maximum height. Find the angle of projection.

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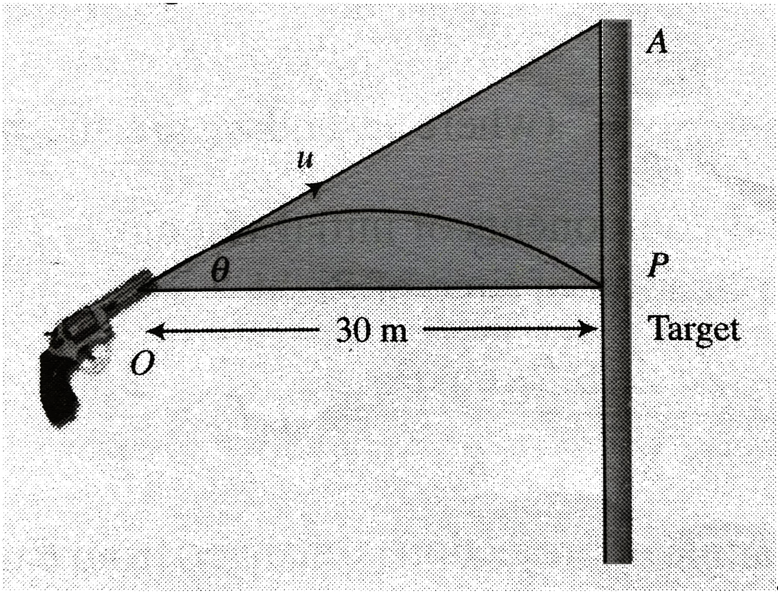
7. A bulley with muzzle velocity $100ms^{-1}$ is to be shot at a target $30m$ away in the same horizontal line. How high above the target must the rifle be aimed so that the bullet will hit the target ?



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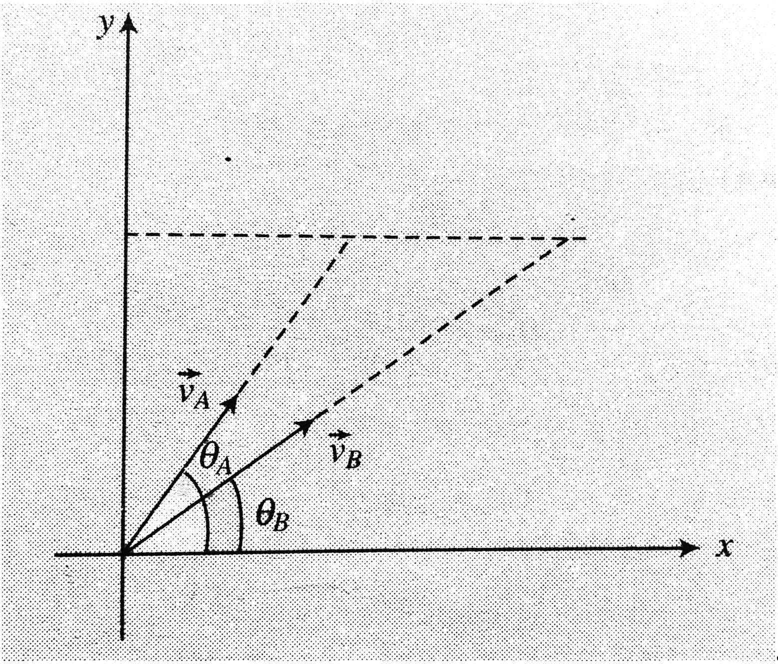
8. Two particles A and B are projected from the same point in different directions in such a manner that vertical components of their

initial velocities are same (Fig. 5.8). Find the ratio of range.



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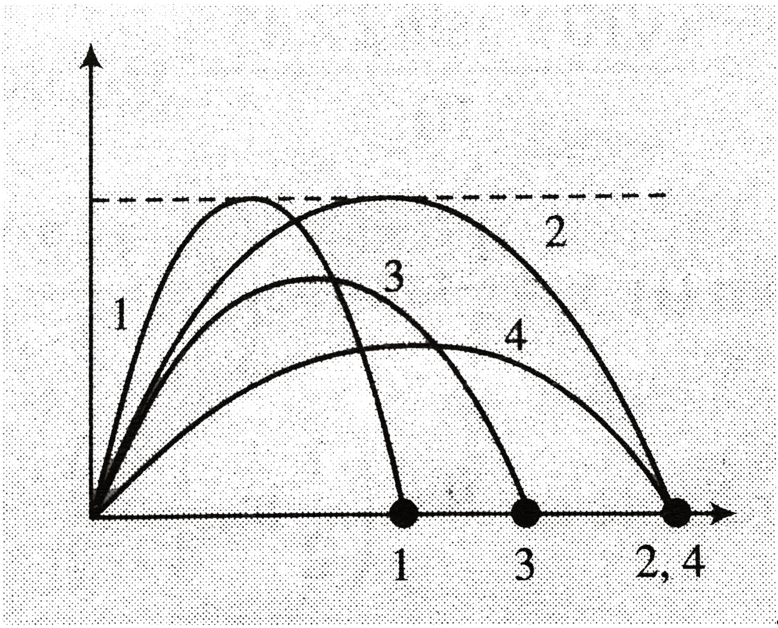
9. Four cannon balls, $(1), (2), (3),$ and (4) are fired from level ground. Cannon ball (1) is fired at an angle of 60° above the horizontal and follows the path shown in (Fig. 5.9).



Cannon balls (2) and (3) are fired at angle of 45° and (4) is fired at an angle of 30° above the horozontal. Which cannon ball has the largest initial speed ?

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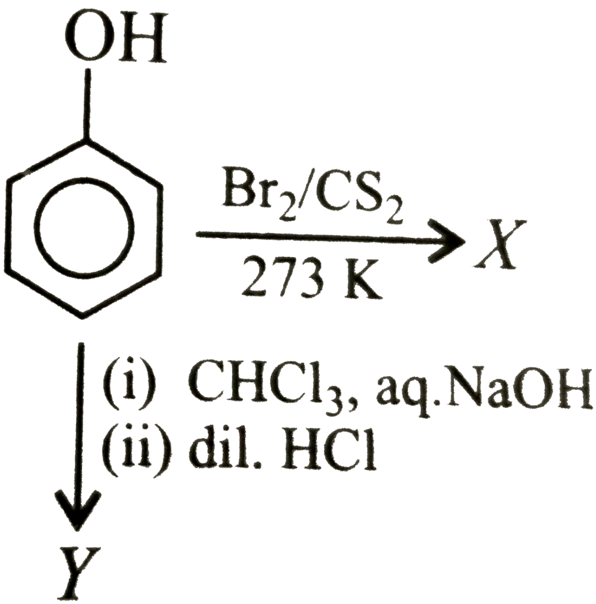
10. In this given reactions,



X and Y are respectively

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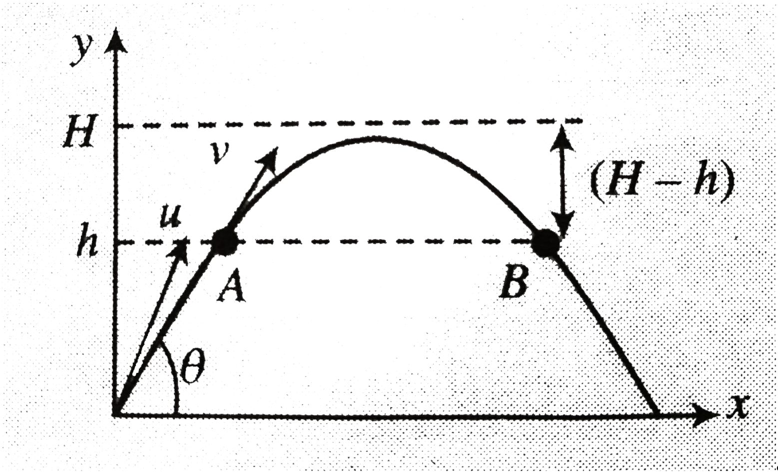
11. (Figure 5.11) shows two positions A and B at the same height h above the ground. If the maximum height os the projectile is H, then determine the time t elapses between the positions A and B in terms of H.



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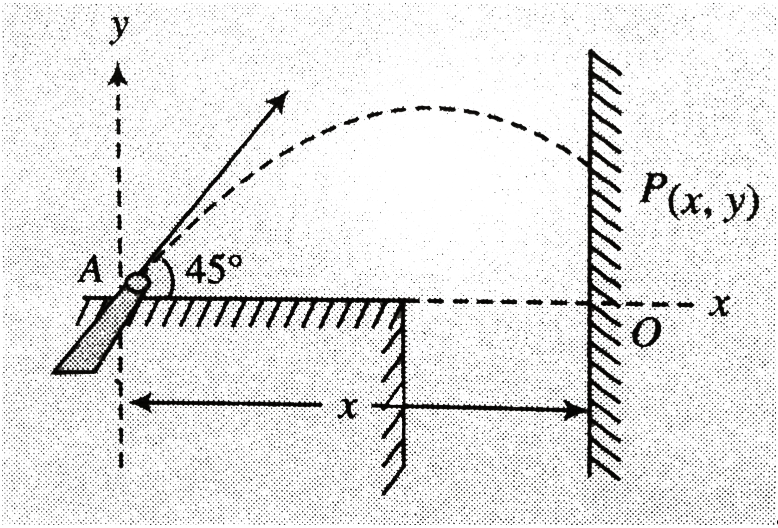
12. A jet of water is projected at an angle $\theta = 45^\circ$ with horizontal from point A which is situated at a distance $x = OA = (a) 1/2m, (b) 2m$ from a vertical wall. If the speed of projection is $v_0 = \sqrt{10ms^{-1}}$, find point P of strinking of the water jet with the vertical wall.



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13. A particle is projected from the ground at $t = 0$ so that on its way it just clears two vertical walls of equal height on the ground. The particle was projected with initial velocity u and at angle θ with the horiozontal. If the particle passes just grazing top of the wall at time $t = t_1$ and $t = t_2$, then calculate.

(a) the height of the wall.

(b) the time t_1 and t_2 in terms of height of the wall.

Write the expression for calculating the range of this projectile and separation between the walls.

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14. From a point on the ground at a distance a from the foot of a pole, a ball is thrown at an angle of 45°, which just touches the top of the pole and strikes the ground at a distance of b, on the outer side of it. Find the height of the pole.

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15. A particle is thrown over a triangle from one end of a horizontal base and after grazing the vertex falls on the other end of the base. If α and β be the base angles and θ the angle of projection, prove that $\tan\theta = \tan\alpha + \tan\beta$.

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16. A particle projected atv a definite angle $\propto$ to the horizontal passes through points (a, b) and (b, a), referred to horizontal and vertical axes through the points of projection. Show that :

(a) The horizontal range $R = \dfrac{a^2 + ab + b^2}{a + b}$.

(b) The angle of projection $\propto$ is given by

$\tan^{-1}\left[\dfrac{a^2 + ab + b^2}{ab}\right]$.

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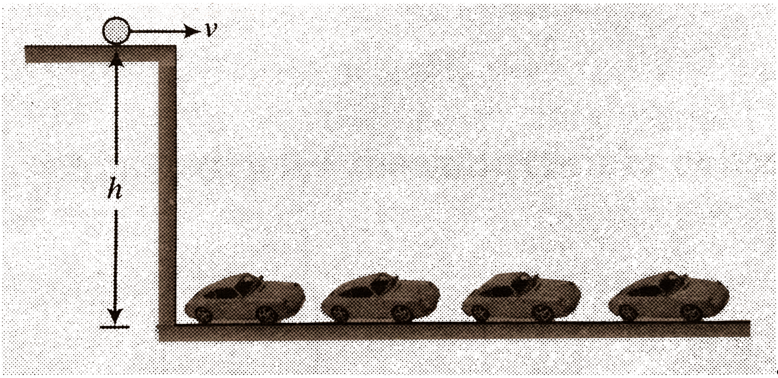
17. A rubber ball escapes from the horizontal roof with a velocity $v = 5ms^{-1}$. The roof is situated at a height, $h = 20m$. If the length of each car is equal to $x_0 = 4m$, with which car will the ball hit ?



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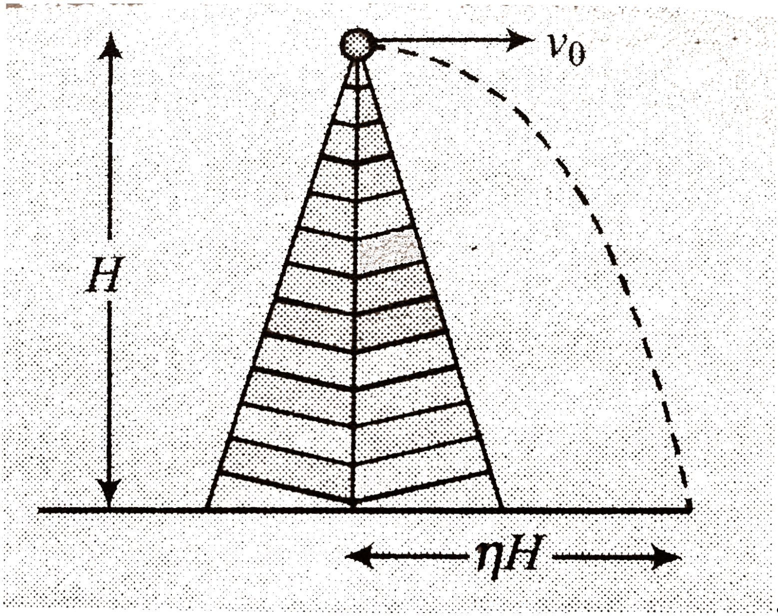
18. (a) With what velocity (v_0) should a ball be projected horizontally from the top of a tower so that the horizontal distance on the ground is ηH, where H is the height of the tower ?

(b) Also determine the speed of the ball when it reaches the ground.



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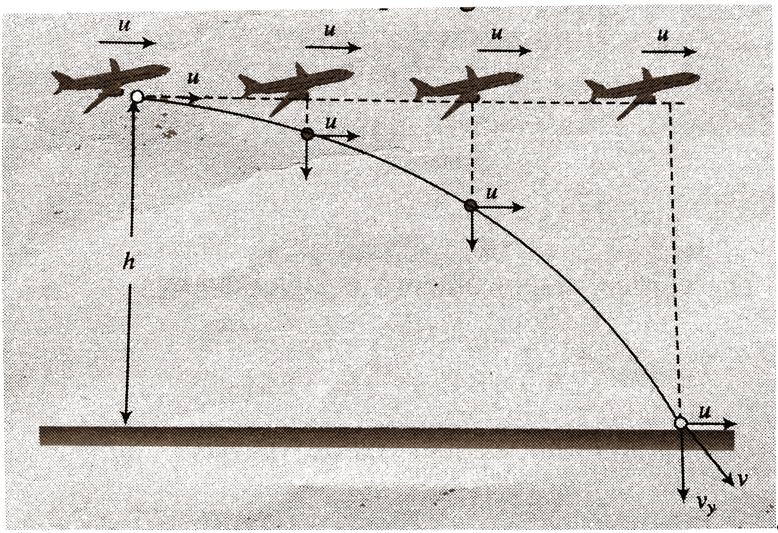
19. A relief food package is dropped from a airplane which is moving horizontal with a velocity of $30 ms^{-1}$ at a height $h = 50 m$. Find the (a) time of flight of the package, (b) location of the point of striking of the food package, (c) velocity of the package at the time of striking the ground, and (d) displacement of the food package.



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20. A ball is thrown from the top of a building $45m$ high with a speed $20ms^{-1}$ above the horizontal at an angle of 30°. Find

(a) The time taken by the ball to reach the ground.

(b) The speed of ball just before it touches the ground.

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21. A boy of height $1.5m$, making move on a skateboard due east with velocity $4ms^{-1}$, throws a coin vertically up a velocity of $3ms^{-1}$ relative to himself.

(a) Find the total displacement of the coin relative to ground till it comes to the hand of the boy.

(b) What isthe maximum height attained by the coin w.r.t. to ground ?

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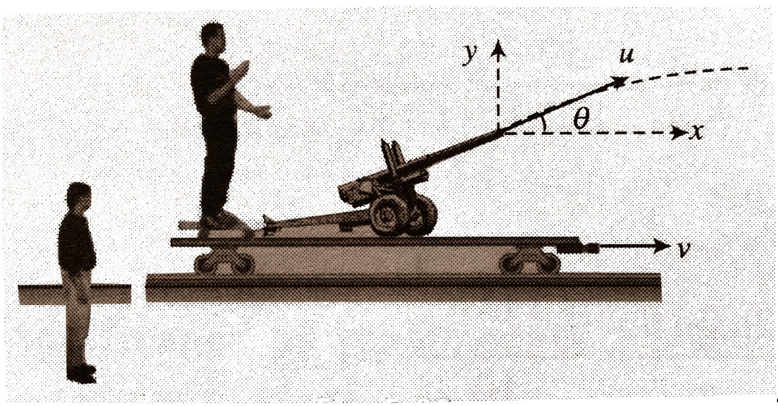
22. A shell is projected from a gun with a muzzle velocity, u. The gun is fitted with a trolly car at an angle θ as shown in (Fig. 5.33). If the trolley car is made to move with constant velocity v towards right, find the

(a) horizontal range of the shell relative to ground.

(b) horizontal range of the shell relative to a person travelling with trolley.



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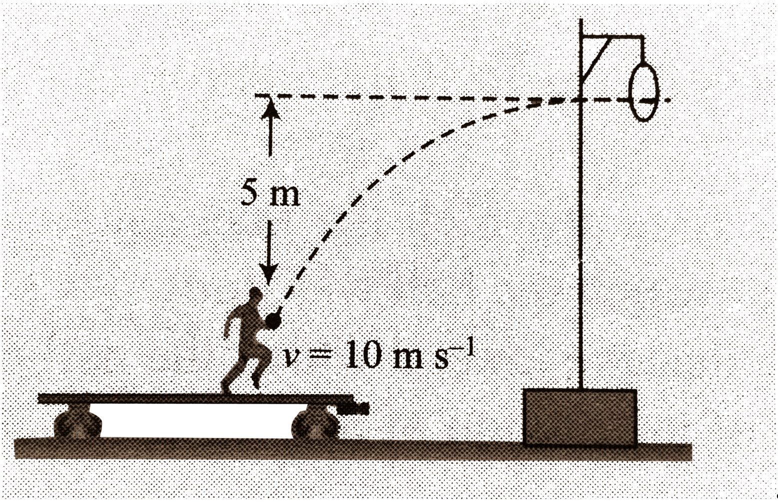
23. A man is standing on a rail road car travelling with a constant speed of $v = 10ms^{-1}$ (Fig . 5.34). He wishes to throw a ball through a stationary hoop $5m$ above the height of his hands in such a manner that the ball will move horizontally as it passes through the hoop. He throws the ball with a speed of $12.5ms^{-1}$ w.r.t. himself.

(a) What must be the vertical component of the initial velocity of the ball ?

(b) How many seconds after he releases the ball will it pass through the hoop ?

(c) At what horizontal distance in front of the loop must he release the ball ?



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24. A person is standing on a truck moving with a constant velocity of 14.7 m/s o a hrozontal road. The man throws a ball in such a way that it returns to the truck after the truck has moved 58.8 m. Find the speed and the angle of projection. a. as seen from the truck b. as seen fromt the road.

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25. A particle is projected with velocity u at angle θ with horizontal. Find the time when velocity vector is perpendicular to initial velocity vector.

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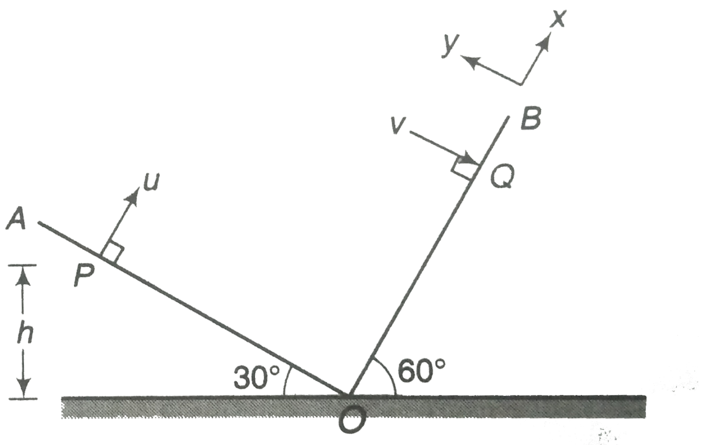
26. Two inclined planes OA and OB having inclinations 30° and 60° with the horizontal respectively intersect each other at O, as shown in figure. A particle is projected from point P with velocity $u = 10\sqrt{3} m/s$ along a direction perpendicular to plane OA. If the particle strikes plane OB perpendicular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



(a) time of flight,

(b) velocity with which the particle strikes the plane OB,

(c) height h of point P from point O,

(d) distance PQ. (Take $g = 10m/s^2$)

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27. A truck starts from rest and accelerates uniformly at $2.0ms^{-2}$. At t = 10 s , a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What are th (a) velcity , and (b) acceleration of the stone at t = 11 s ? (Neglect air resistance).

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28. A body is thrown at an angle θ_0 with the horizontal such that it attains a speed equal to $\sqrt{\frac{2}{3}}$ times the speed of projection when the body is at half of its maximum height. Find the angle θ_0.

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29. A particle is projected at an angle of elevation α and after t second it appears to have an elevation of β as seen from the point of projection. Find the initial velocity of projection.

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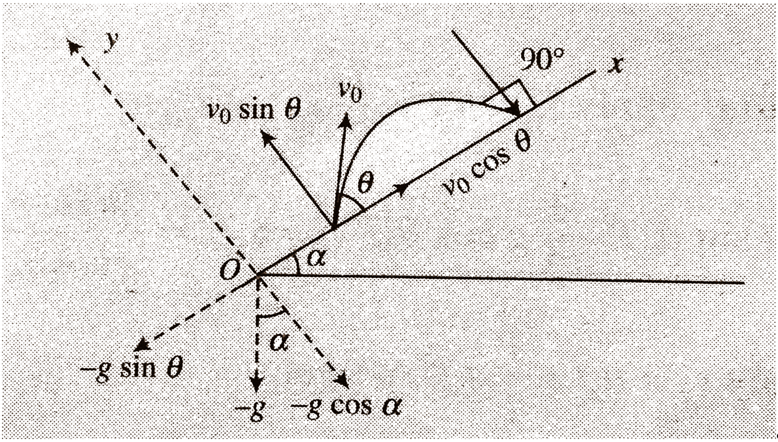
30. At what angle should a ball be projected up an inclined plane with a velocity v_0 so that it may hit the incline normally. The angle of the inclined plane with the horizontal is $\propto$.



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31. A body is projected up with a speed v_0 along the line of greatest slope of an inclined plane of angle of inclination β. If the body collides elastically perpendicular to the inclined plane, find the time after which the body passes through its point of projection.

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32. An inclined plane makes an angle $\theta_0 = 30^\circ$ with the horizontal. A particle is projected from this plane with a speed of $5ms^{-1}$ at an angle of elevation $\beta = 30^\circ$ with the horizontal as shown in (Fig. 5.53).

(a) Find the range of the particle on the plane when it strikes the plane.

(b) Find the range of the particle for $\beta = 120^{\circ}$

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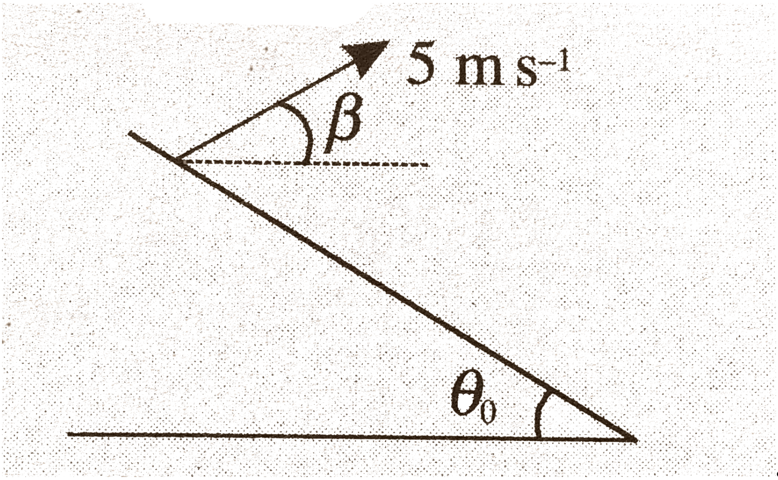

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33. A body has maximum range R_1 when projected up the plane. The same body when projected down the inclined plane, it has maximum range R_2. Find the maximum horizontal range. Assume equal speed of projection in each case and the body is projected onto the inclined plane in the line of the greatest slope.

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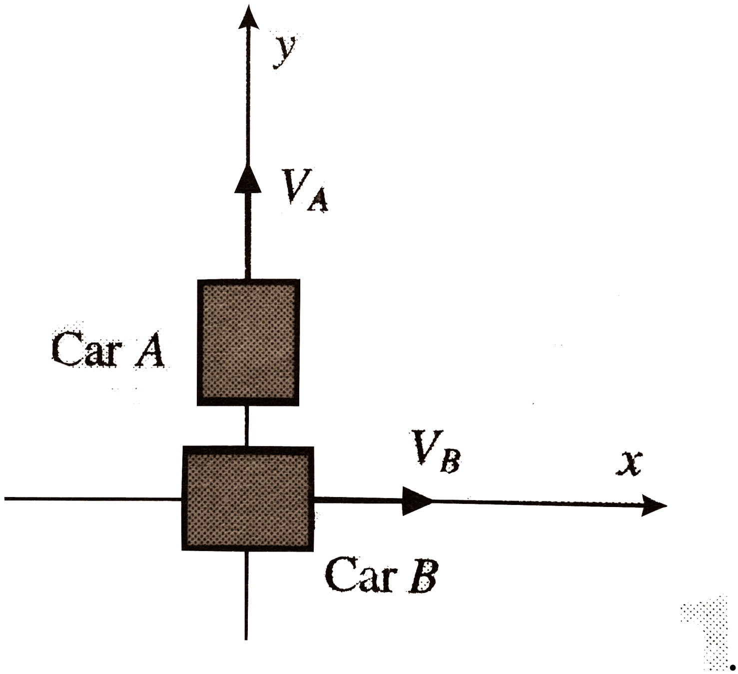
34. Two roads interest at right angle , one goes along the x - axis, another along the y - axis. At any instant, two cars $A bad B$ moving along y and x directions, respectively, meet at intersection. Draw the direction of the motion of car A as seen from car B.



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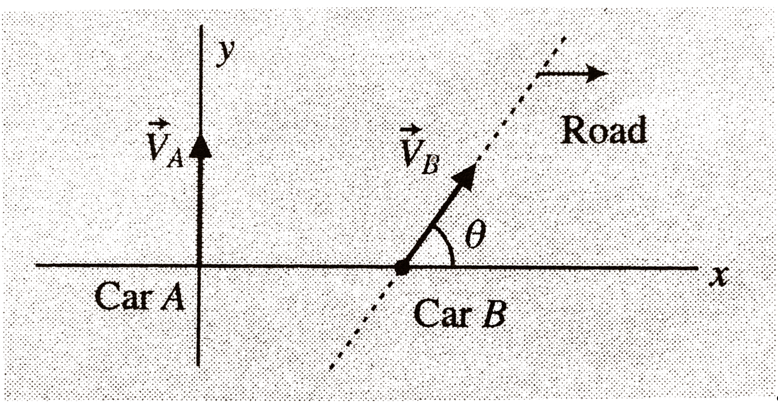
35. Two roads one , along the y - axis and another along a direction at angle θ with x - axis, are as shown in (Fig. 5.68). Two cars A and B are moving along the roads. Considerthe situation of the diagram. Draw the direction of

(a) Car B as seen from car A.

(b) Car A as seen car B.



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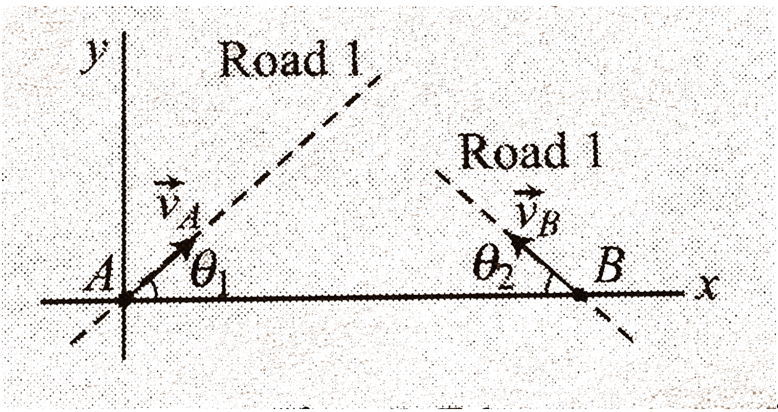
36. Consider the situation given in (Fig. 5.71). Two cars are moving along road 1 and 2. Draw the direction of the motion of

(a) Car B as seen from car A.

(b) Car A as seen from car B.



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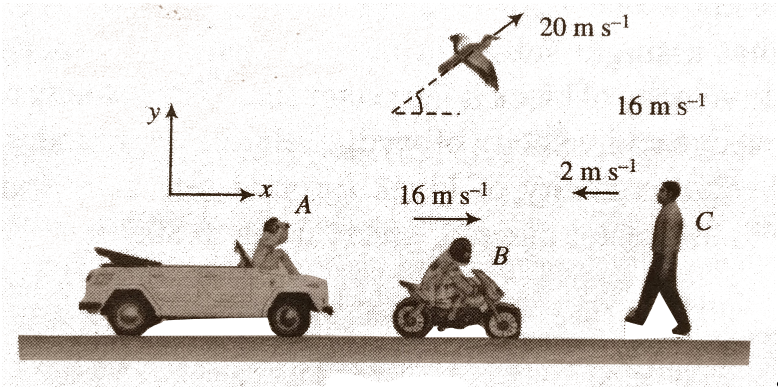
37. A man A is sitting in a car at rest observes a man B on bike moving away from him with velocity $16ms^{-1}$, a man C walking on road with velocity $2ms^{-1}$ towards him and a bird flying with spedd $20ms^{-1}$ at angle 37° with horizontal as shown in (Fig. 5.74). Find the

(a) velocity of car, bird, and man C as seen by man B.

(b) velocity of car, bird, man B as seen by man C

(c) velocity of car, man B, and man C as seen by bird.



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38. Ram Shyam are walking on two perpendicular tracks with speed $3ms^{-1}$ and $4ms^{-1}$, respectively. At a certain moment $(t = 0s)$, Ram and Shyam are at 20 m and 40 m away from the intersection of tracks, respectively, and moving towards the intersection of the tracks.

During the motion the magnitude of velocity of ram with respect to Shyam is

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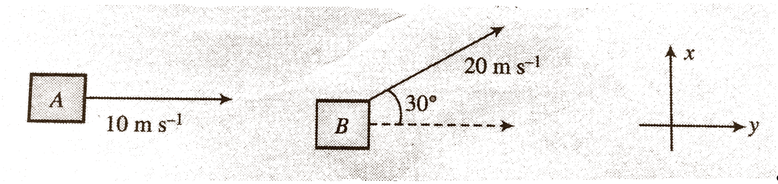
39. Two objects A and B are moving along the directions as shown in (Fig. 5.77). Find the magnitude and direction of the relative velocity of $B w.r.t. A$.



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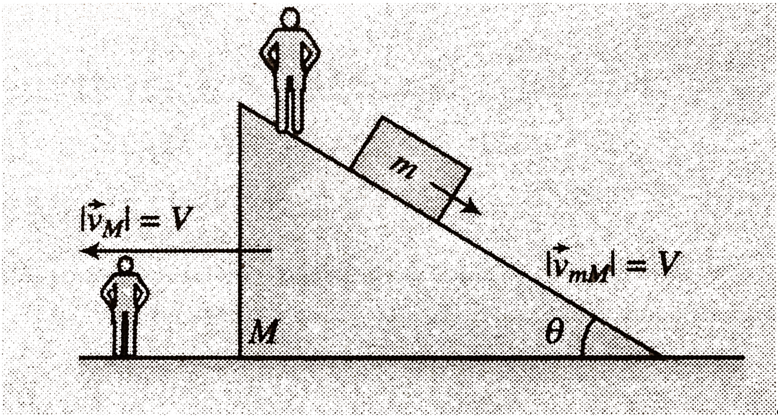
40. A block slips along an incline of a wedge. Due to the reaction of the block on the wedge, it slips backwards. An observer on the wedge will see the block moving straight down the incline. Discuss how to find the absolute velocity of the block.



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41. A political party has to start its procession in an area where wind is blowing at a speed of $30\sqrt{2}kmh^{-1}$ and party flags on the cars are fluttering along north - east direction. If the procession starts with a speed of $40kmh^{-1}$ towards north, find the direction of flags on the cars.

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42. A bird is fying due east with a velocity of $4ms^{-1}$. The starts to blow with a velocity of $3ms^{-1}$ due north. What is the magnituide of relative velocity of bird w.r.t. wind ? Find out its direction also.

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43. A truck is moving with a constant velocity of $54 kmh^{-1}$. In which direction (angle with the direction of motion of truck) should a stone be projected up with a velocity of $20 ms^{-1}$, from the floor of the truck of the truck, so as to appear at right angles to the truck, for a person standing on earth ?

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44. A man crosses a river in a boat. If he cross the river in minimum time he takes 10 min with a drift $120m$. If he crosses the river taking shortest path, he takes 12.5 min , find

(a) width of the river

(b) velocity of the boat with respect to water

(c) speed of the current

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45. A man can swim at the rate of $5kmh^{-1}$ in still water. A $1-km$ wide river flows at the rate of $3kmh^{-1}$ The man wishes to swim across the river directly opposite to the starting point.

(a) Along what direction must the man swim ?

(b) What should be his resultant velocity ?

(c) How much time will he take to cross the river ?

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46. A river flows due south with a speed of $2.0ms^{-1}$. A man strees a motorboat across the river , his velocity relative to the water is $4ms^{-1}$ due east. The river is $800m$ wide.

(a) What is his velocity (magnitude and direction) relative to the earth ?

(b) How much time is required to cross the river ?

(c) HOw far south of his starting points will he reach the opposite bank ?

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47. A man can swim at the rate of $5 km h^{-1}$ in still water. A $1 - km$ wide river flows at the rate of $3 km h^{-1}$ The man wishes to swim across the river directly opposite to the starting point.

(a) Along what direction must the man swim ?

(b) What should be his resultant velocity ?

(c) How much time will he take to cross the river ?

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48. A boat moves relative to water with a velocity v which is n times less than the river flow velocity u. At what angle to the stream direction must the boat move to minimize drifting ?

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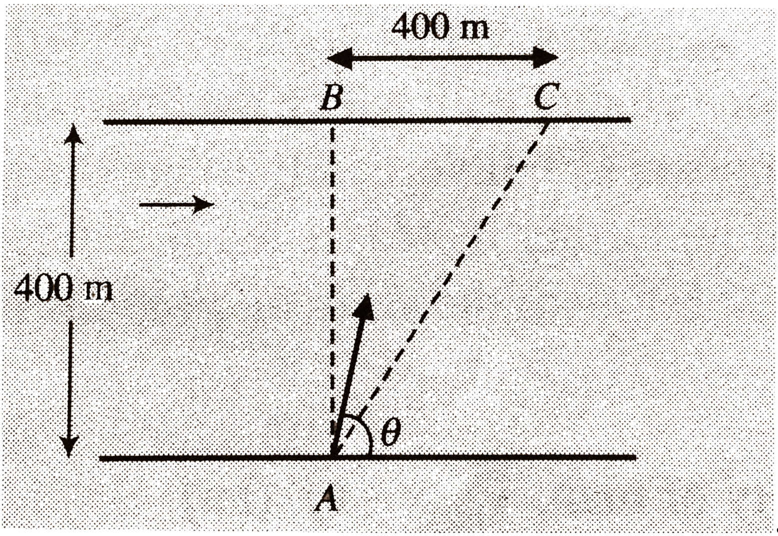
49. A river is flowing with a speed of $1 km h^{-1}$ A swimmer wants to go point C starting from A. He swims with a speed of $5 km h^{-1}$ at an angle θ w.r.t. the river flow. If $AB = BC = 400m$, at what angle with the river bank should the swimmer swim ?



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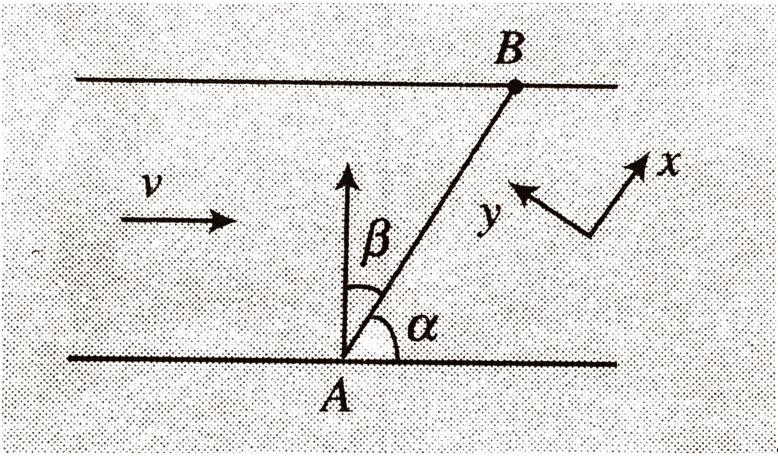
50. A man wants to swim in a river from $A \rightarrow B$ and back from $B \rightarrow A$ always following line AB (Fig. 5.94). The distance between points A and B is S. The velocity of the river current v is constant over the entire width of the river. The line AB makes an angle $\propto$ with the direction of current. The man moves with velocity u at angle β to the line AB. The man swim to cover distance AB and back, find the time taken to complete the journey.



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51. Rain is falling vertically with velocity 10m /s and a man is moving with velocity $6ms^{-1}$. Find the angle at which the man should hold his umbrella to above getting wet.

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52. A man moving with $5ms^{-1}$ observes rain falling vertically at the rate of $10ms^{-1}$. Find the speed and direction of the rain with respect to ground.

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53. A standing man observes rain falling with the velocity of $20ms^{-1}$ at an angle of 30° with the vertical.

(a) Find the velocity with which the man should move so that rain appears to fall vertically to him.

Now if he further increases his speed, rain again appears to fall at 30° with the vertical. Find his new velocity.

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54. A person standing on a road has to hold his umbrella at 60^0 with the verticcal to keep the rain away. He throws the umbrella an starts running at $20ms^{-1}$. He finds that rain drops are hitting his head vertically. Find the speed of the rain drops with respect to (a) the road (b) the moving person.

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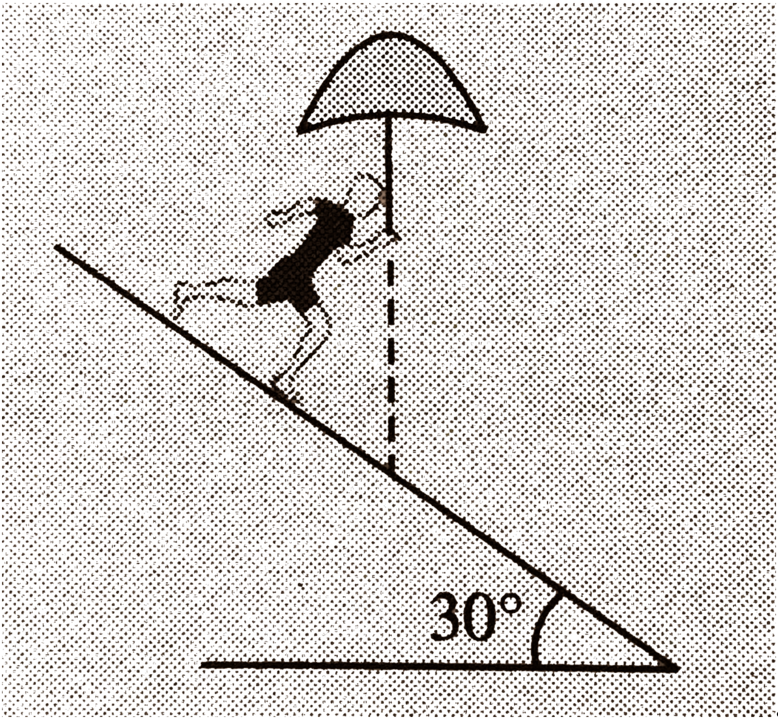
55. A man is coming down an incline of angle 30°. When he walks with speed $2(\sqrt{3})ms^{-1}$ he has to keep his umbrella vertical to protect himself from rain. The actual speed of rain is $5ms^{-1}$. At angle with vertical should he keep his umbrella when he is at rest so that he does not getb drenched ?



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56. During a rainy day, rain is falling vertically with a velocity $2m/s$ A boy at rest starts his motion with a constant acceleration of $2m/s^2$ along a straight road . Find the rate at which the angle of the axis of umbrella with vertical should be changed so that the rain always falls parallel to the axis of the umbrella.

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57. An aeroplane pilot wishes to fly due west A wind of $100 kmh^{-1}$ is blowing towards south.

(a) If the speed of the plane (its speed in still air) is $300 kmh^{-1}$ in which direction should the pilot head ?

(b) What is the speed of the plane with respect tom ground ? Illustrate with a vector diagram.

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58. An aeroplane has a velocity of 110 m/s directed due north and is subjected to a wind blowing from west to east at a speed of 40 m/s . Calculate the actual velocity of the aeroplane relative to the earth .

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59. $A, B, C,$ and D are four trees, located at the vertices of a square (Fig. 5.117). Wind blows from $A \rightarrow B$ with uniform speed. The ratio of times of flight of a bird from $A \rightarrow B$ and from $B \rightarrow A$ is n. At what angle should the bird fly from the direction of wind flow, in order that it starts from A and

(a) reaches C,

(b) reaches D ?

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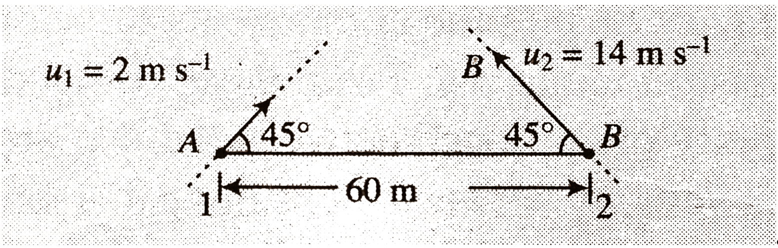
60. Two particles are located on a horizontal plane at a distance $60m$. At $t = 0$ both the particles are simultaneously projected at angle 45° with velocities $2ms^{-1}$ and $14ms^{-1}$, respectively. Find

(a) Minimum separation between them during motion.

(b) At what time is the separation between them minimum ?



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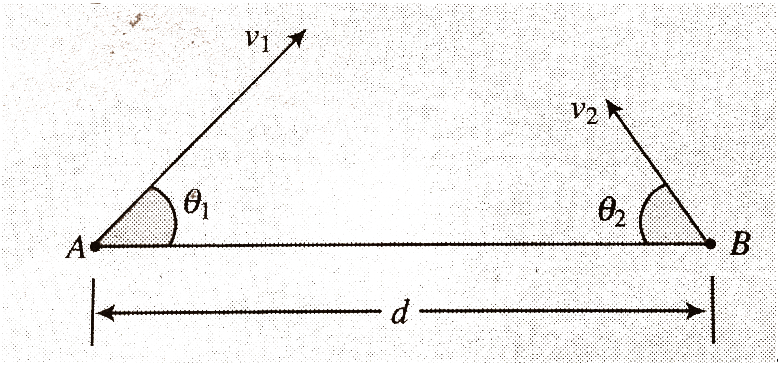
61. Two particles A and B are moving with constant velocities v_1 and v_2. At $t = 0$, v_1 makes an angle θ_0 with the line joining A and B and v_2 makes an angle θ_2 with the line joining A and B.

(a) Find the condition for A and B to collide.

(b) Find the time after which A and B will collide if separation between them is d at

$t = 0$.



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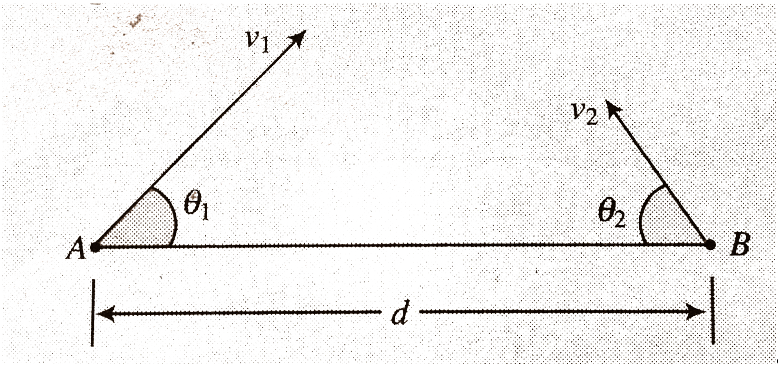
62. Two particles A and B are moving with constant velocities v_1 and v_2. At $t = 0$, v_1 makes an angle θ_0 with the line joining A and B and v_2 makes an angle θ_2 with the line joining A and B.

(a) Find the condition for A and B to collide.

(b) Find the time after which A and B will collide if separation between them is d at $t = 0$.



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63. Two cars A and B are moving west to east and south to north, respectively, along crossroads. A moves with a speed of $20 m s^{-1}$ and is $500 m$ away from the point of intersection of cross roads and B moves with a speed of $15 m s^{-1}$ and is $400 m$ away from the point of intersection of cross roads. Find the shortest distance between them.

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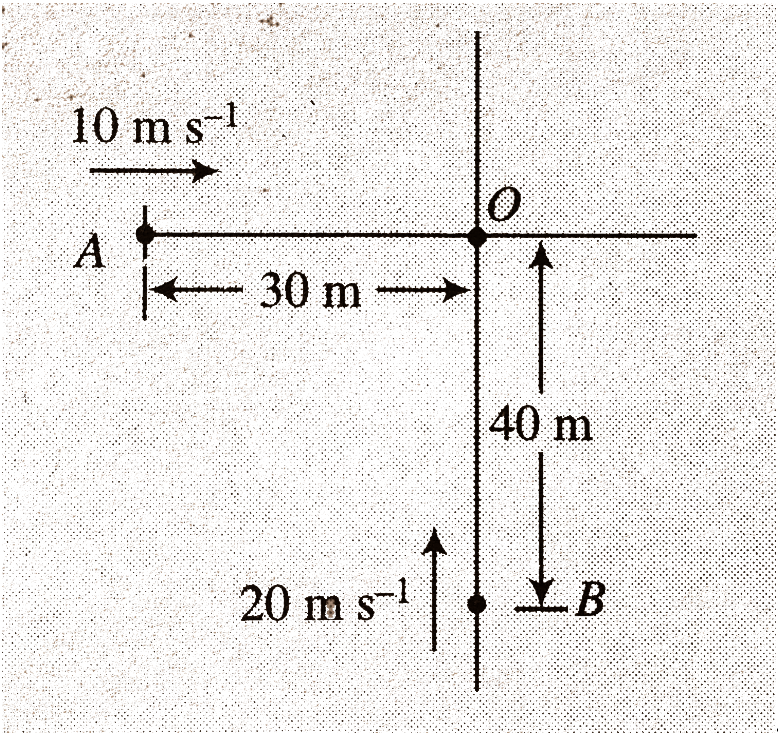
64. Two particles A and B are moving with uniform velocity as shown in (Fig. 5.130) given below at $t=0$.

(a) Will the two particles collide ?

(b) Find out the shortest distance between two particles.



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65. Three particles A, B and C are situated at the vertices of an equilateral triangle ABC of side d at time $t = 0$. Each of the particles moves with constant speed v. A always has its velocity along AB, B along BC and C along CA. At what time will the particles meet each other?

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66. In a clock, what is the time period of meeting of the minute hand and the second hand ?

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67. A particle moves in a circle of radius 2 cm at a speed given by v = 4 t, where v is in cms^{-1} and t in second.

(i) Find the tangential acceleration `at=1 s.

(ii) Find total acceleration at t = 1 s.

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68. A particle moves on a circle of radius r with centripetal acceleration as function of time as $a_c = k^2 r t^2$, where k is a positive constant. Find the following quantities as function of time at an instant :

(a) The speed of the particle

(b) The tangential acceleration of the particle

(c) The resultant acceleration, and

(d) Angle made by the resultant acceleration with tangential acceleration direction.

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69. A particle moves in a circular path such that its speed $1v$ varies with distance s as $v = \sqrt{s}$, where $\propto$ is a positive constant. Find the acceleration of the particle after traversing a distance s.

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70. The tangential acceleration of a particle moving in a circular path of radius $5cm$ is

$2ms^{-2}$. The angular velocity of the particle increases from $10rads^{-1}$ to $20rads^{-1}$ during some time. Find

(a) this duration od time and

(b) the number of revolutions completed during this time.

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71. A fan is rotating with angular velocity $100revs^{-1}$. Then is switched off. It takes $5 \min$ to stop.

(a) Find the total number of revolution made before the fan stops. (assume uniform angular retardation).

(b) Find the value of angular retardation.

(c) Find the average angular velocity during this interval.

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72. Two particles A and B move on a circle Initially, particles A and B are diagonally opposite to each other. Particle A moves with angular velocity $\pi rads^{-1}$ and angular acceleration $\pi/2rads^{-2}$ and particle B moves with constant angular velocity $2\pi rads^{-2}$. Find the time after which both the particlsd $AnadB$ will collide.

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73. A stone tied to an inextensible string of length $l = 1m$ is kept horizontal. If it is released, find the angular speed of the stone when the string makes an angle $\theta = 30^\circ$ with horizontal.

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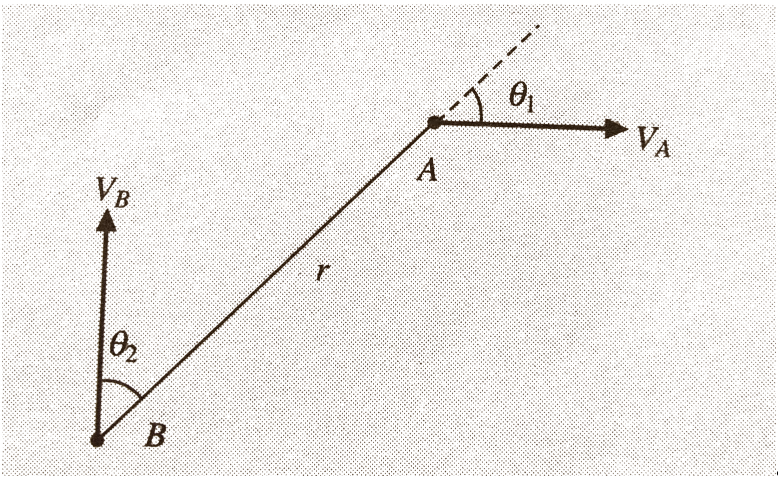
74. Find the angular velocity of A with respect to B in (Fig. 5.156).



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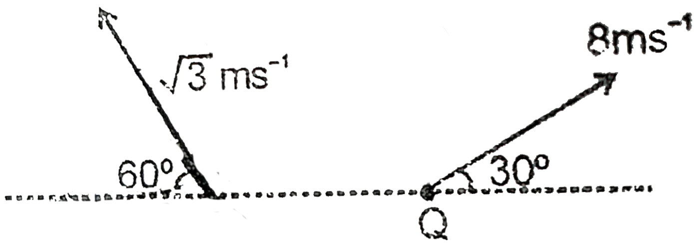
75. Two particles P and Q are moving as shown in the figure. At this moment of time the angular speed of P w.r.t. Q is



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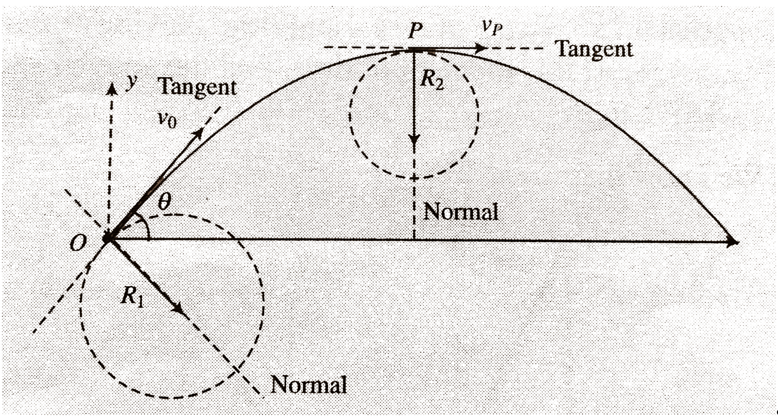
76. A particle is projected at angle θ with horizontal with velocity $v_0 att = 0$. Find

(a) tangential and normal acceleration of the particle at $t = 0$ and at highest point of its trajectory.

(b) the radius of curvature $a = 0$ and highest point.



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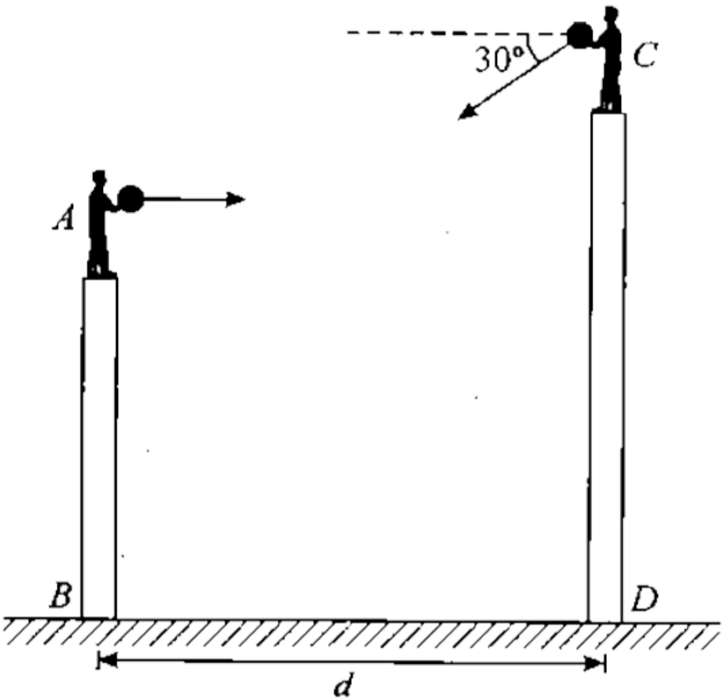
Solved Examples

1. Two towers AB and CD are situated at a distance d apart, as shown in figure. AB is 20 m high and CD is 30 m high from the ground. An object of mass m is thrown from the top of AB horizontally with a velocity of 10 m/s towards CD. Simultaneously another object of mass 2 m is thrown fromt the top of CD at an angle of 60° to the horizontal towards AB with the same magnitude of initial velocity as that oft he first object. The two objects move in the same vertical plane, collide in mid air and stick to each other (i) calculate the distance between the towers and (ii) find the position where the objects hit the ground.



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2. Two particle are projected with same initial velocities at an angle 30° and 60° with the horizontal .Then

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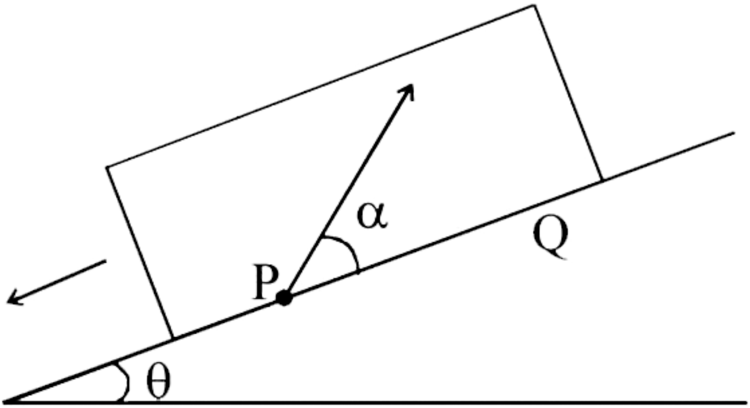
3. A large , heavy box is sliding without friction down a smooth plane of inclination θ . From a point P on the bottom of the box , a particle is projected inside the box . The initial speed of the particle with respect to the box is u , and the direction of projection makes an angle α with the bottom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

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

(b) If the horizontal displacement of the particle as seen by an observer on the ground is zero , find the speed of the box with respect to the ground at the instant when particle was projected .



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4. Find the point on the curve $y^2 = ax$ the tangent at which makes an angle of 45^0 with the x-axis.

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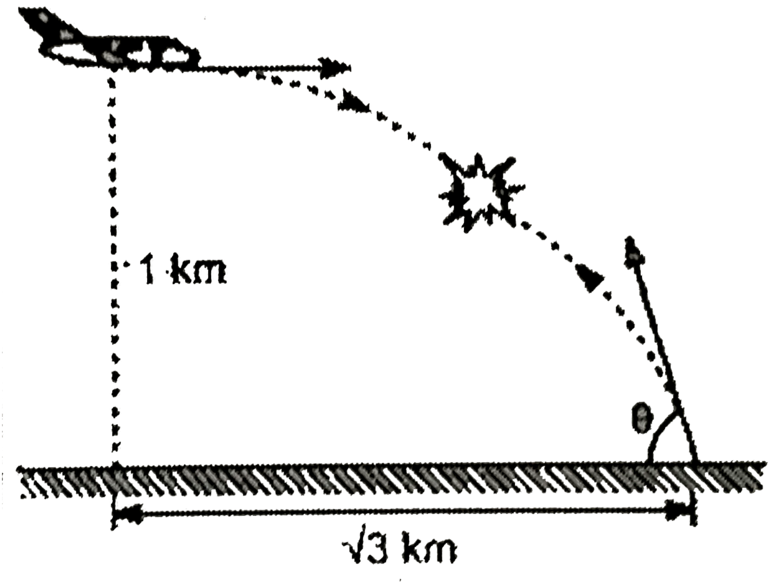
5. An aircraft is .flying. horizontally with a constant vefocity $=200m/s$ at a height $=1km$ above groun At the momement shown, a bomb is released from the aircraft and the cannon-gun below fires a shell with initial speed $=200m/s$, at some angle θ For what value of θ will the projectile shell destroy the bomb in mid-air? If the value of θ is 53^{3}, find the minimum distance between the bomb and the shell as they fly past each other. Take

$\sin 53^{\circ} = 4/5$



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6. The speed of a boat in still water is 15 km/hr.

It can go 30 km upstream and return

downstream to the original point in 4 hours 30 minutes. Find the speed of the stream.

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7. Three particles A, B and C are situated at the vertices of an equilateral triangle ABC of side d at time $t = 0$. Each of the particles moves with constant speed v. A always has its velocity along AB, B along BC and C along CA. At what time will the particles meet each other?

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Exercise 5.1

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

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2. A body starts from the origin with an acceleration of $6ms^{-2}$ along the x - axis and

$8ms^{-2}$ along the y - axis. Find its distance from the origin after $4s$.

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3. A particle is thrown with velocity u at an angle $\propto$ from the horizontal. Another particle is thrown with the same velocity at an angle $\propto$ from the verticle. What will be the ratio of times of flight of two particles ?

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4. The friction of the air causes a vertical retardation equal to 10% of the acceleration due to gravity $\left(takeg = 10ms^{-2}\right)$ The maximum height will be decreased by:

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5. A boy playing on the roof of a $10m$ high building throws a ball with a speed of $10m/s$ at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the

height of $10m$ from the ground ?

$$\left[g = 10m/s^2, \sin 30^\circ = \frac{1}{2}, \cos 30^\circ = \frac{\sqrt{3}}{2}\right]$$

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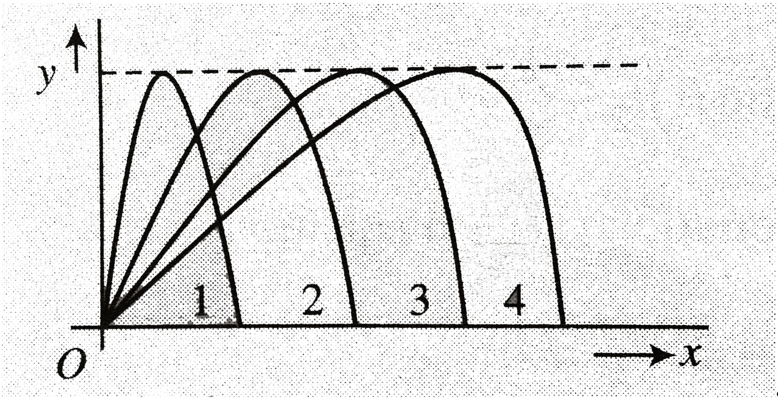
6. Figure shows four paths for a kicked football. Ignoring the effects of air on the flight, rank the paths according to the initial horizontal velocity component, highest first.



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7. A projectile is thrown into space so as to have maximum horizontal range R. Taking the point of projection as origin, find out the co-ordinates of the point where the speed of the particle is minimum.

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8. A gun is firing bullets with velocity v_0 by rotating it through 360° in the horizontal plane. The maximum area covered by the bullets is

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9. A projectile thrown with an initial speed u and the angle of projection 15° to the horizontal has a range R. If the same projectile is thrown at an angle of 45° to the horizontal with speed $2u$, what will be its range ?

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10. Two particles are projected from the same point with the same speed u such that they have the same range R, but different maximum heights, h_1 and h_2. Which of the following is correct ?

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11. A grass hopper can jump maximum distance $1.6m$. It spends negligible time on ground. How far can it go in $10\left(\sqrt{2}\right)$s?

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12. A projectile is thrown with an initial velocity of $v = a\hat{i} + b\hat{j}$. If the range of projectile is double the maximum height reached by it. Find the ratio $\frac{b}{a}$.

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13. A ball of mass M is thrown vertically upwards. Another ball of mass 2M is thrown at an angle θ with the vertical. Both of them stay in air for the same period of time. The heights attained by the two are in the ratio

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14. Two bodies are thrown with the same initial velocity at angles θ and $(90^\circ - \theta)$ respectively with the horizontal, then their maximum height are in the ratio

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15. A ball is thrown at different angles with the same speed u and from the same points and it has same range in both the cases. If y_1 and y_2

be the heights attained in the two cases, then find the value of $y_1 + y_2$.

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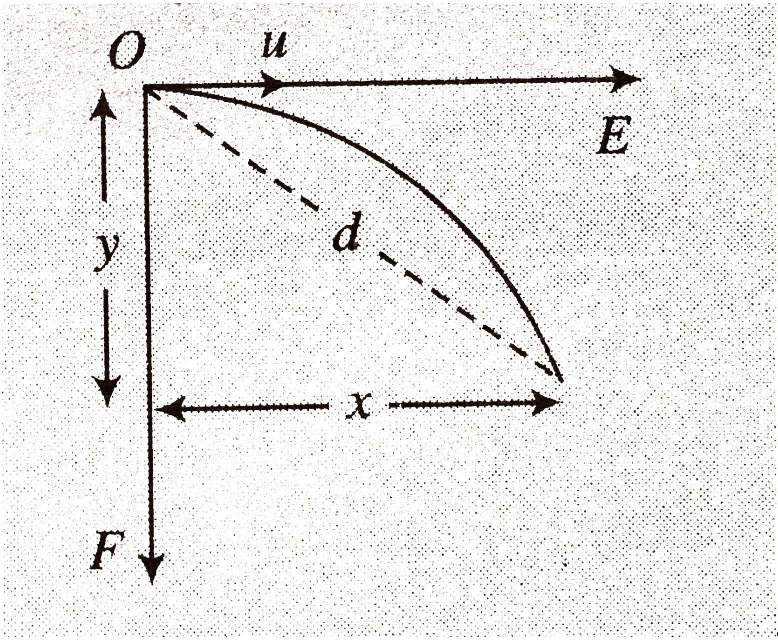
Exercise 5.2

1. A body of mass $2kg$ has an initial velocity of $3ms^{-1}$ along OE and it is subjected to a force of $4N$ in OF direction perpendicular to OE. Find the distance of the body from O

after $4s$.



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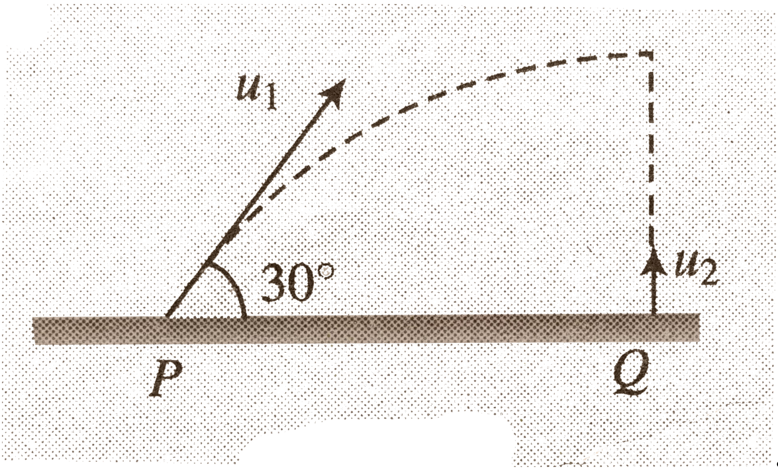
2. A particle P is projected with velocity u_1 at an angle of 30° with the horizontal. Another particle Q is thrown vertically upwards with velocity u_2 from a point vertically below the highest point of path of P. Determine the necessary condition for the two particles to collide at the highest point.



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3. Two seconds after projection, a projectile is travelling in a direction inclined at 30° to the horizontal. After one more second, it is travelling horizontally. Find the magnitude and direction of its velocity.

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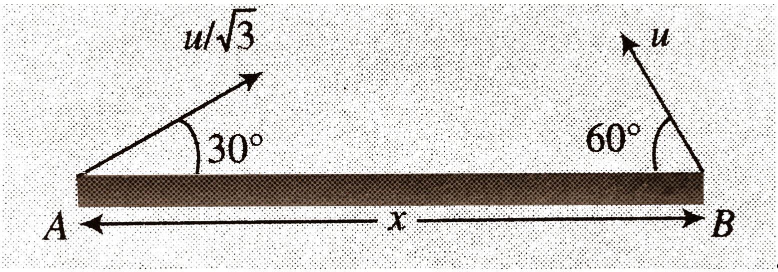
4. Two particles are separated at a horizontal distance x as shown in (Fig. 5.57). They are projected at the same time as shown in the figure with different initial speed. Find the time after which the horizontal distance between the particles becomes zero.



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5. A ball rolls off the a stair way with a horizontal velocity ums^{-1}. If the steps are h metres high and b metres wide, the ball will just hit the edge of nth step is n equals to

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6. A body is projected horizontally from the top of a tower with initial velocity $18ms^{-1}$. It hits the ground at angle 45°. What is the vertical component of velocity when it strikes the ground ?

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7. A man standing on the roof a house of height h throws one particle vertically downwards and another particle horizontally with same velocity u. Find the ratio of their velocities when they reach the earth's surface.

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8. A staircase contains three steps each 10 cm high and 20 cm wide figure. What should be the minimum horizontal velocity of a bal rolling off the upper most plane so as to hit directly the lowest plane?

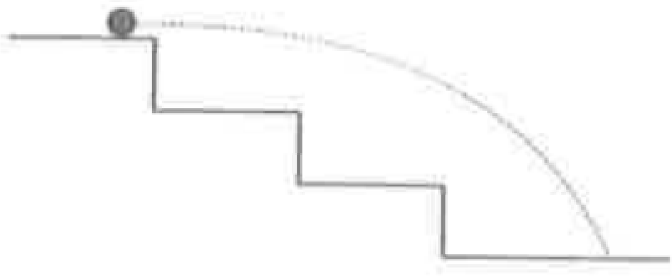

Figure 3-E9

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9. For a given velocity of projection from a point on the inclined plane, the maximum range down the plane is three times the maximum range up the incline. Then find the angle of inclination of the inclined plane.

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10. A shell is fired from a gun from the bottom of a hill along its slope. The slope of the hill is $\propto = 30^\circ$ and the angle of the barrel to the horizontal $\beta = 60^\circ$. The initial velocity v of the shell is $21ms^{-1}$. Then find the distance of point from the gun at which the shell will fall.

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11. The maximum range of a rifle bullet on the horizontal ground is $6km$. Find its maximum range on an inclined of 30°.

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12. A motorcycle stunt rider rides off the edge of a cliff. Just at the edge his velocity is horizontal, with magnitude $9.0ms^{-1}$. Find the motorcycle's position, distance from the edge of the cliff and velocity after $0.5s$.

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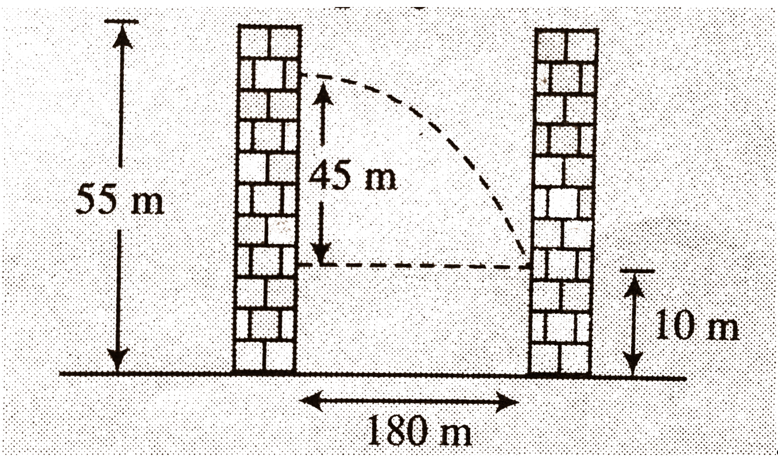
13. An object is thrown between two tall buildings $180m$ from each other. The object thrown horizontally from a window $55m$ above the ground from one buiding strikes a window $10m$ above the ground in another building. Find out the speed of projection.



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14. A fighter plane moving with a speed of $50\sqrt{2}ms^{-1}$ upward at an angle of 45° with the vertical releases a bomb when it was at a height $1000m$ from ground. Find (a) the time of flight

(b) the maximum height of the bomb above ground.

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15. A bullet is fired from the bottom of the inclined plane at angle $\theta = 37^\circ$ with the inclined plane. The angle of incline is 30° with the horizontal. Find the

(a) position of the maximum height of the bullet from the inclined plane ,

(b) time of light ,

(c) range along the incline ,

(d) the value of θ at which the range will be maximum ,

(e) maximum range.

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16. Two paper screens A and B are separated by $150m$. A bullet pierces A and B. The hole in B is $15cm$ below the hole in A. If the bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is $(g = 10ms^{-2})$

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17. Two stones A and B are projected simultaneously from the top of a $100 - m$

high tower. Stone B is projected horizontally with speed $10ms^{-1}$, and stone A is droppd from the tower. Find out the following :

(a) Time of flight of the two stone

(b) Distance between two stones after $3s$

(c) Angle of strike with ground

(d) Horizontal range of particle B.

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18. On an inclined plane two particles A and B are projected with same speed at the same angle with the horizontal, particle A down and particle B up the plane. If the ratio of time of flight of A and B is $\cot\theta$, where θ is the angle at which B is projected measured from inclined plane, find the angle at which particles are projected.

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19. A particle is projected with velocity v at an angle θ aith horizontal. The average angle velocity of the particle from the point of projection to impact equals

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20. The horizontal range (R) of a projectile becomes (R + 2 H) from R due to a wind in horizontal direction. Here H is the maximum height reached by the projectile. What constant horizontal acceleration is imparted by the wind ?

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21. A boy is running along positive x - axis with $9m/s$. While running he manages to throw a stone in a plane perpendicular to his direction of running with velocity $12m/s$ at an angle 30° with vertical. Find the speed of the stone at the highest point of the trajectory.

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22. Two guns are situated at the top of a hill firing the shots at the same speed. One gun

fires the shot horizontally and other gun fires the shot at an angle of 60° with horizontal. Two two shots collide in air. If the time taken by horizontal shot to reach the point of collision in $3\sec onds$, find the time interval between two shots.

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23. A ball is thrown horizontally from the top of a tower and strikes the ground in $3s$ at an angle of 30° with the vertical.

(a) Find the height of the tower.

(b) Find the speed with which the body was projected.

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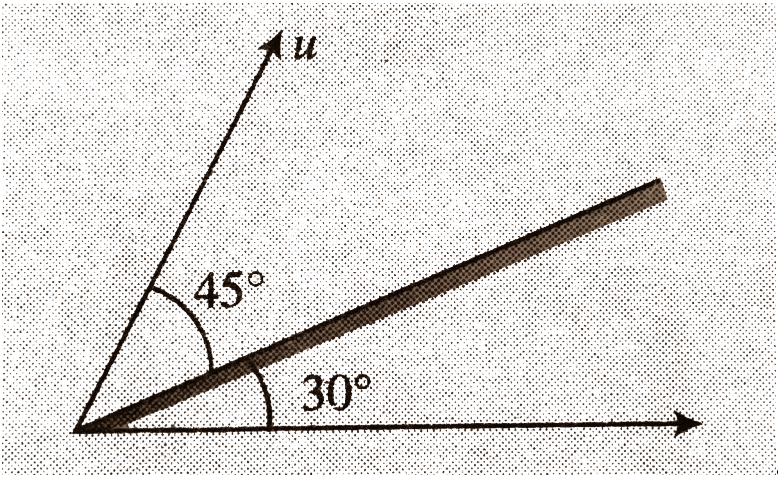
24. A particle is projected on an inclined plane with a speed u as shown in (Fig. 5.61). Find the

range of the particle on the inclined plane.



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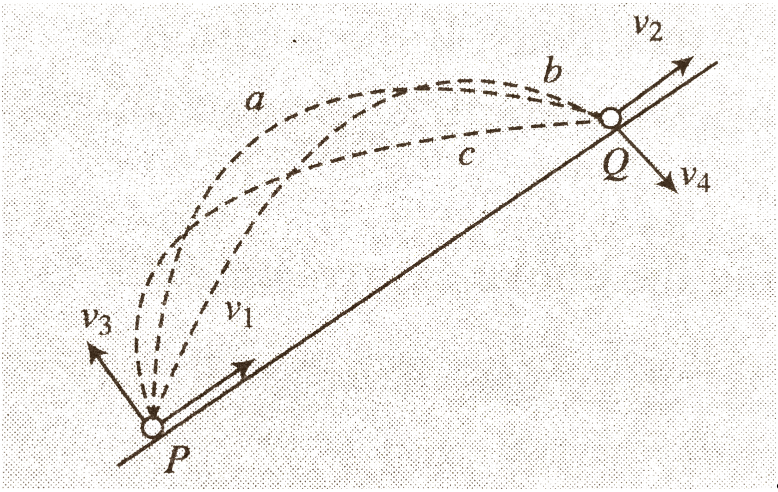
25. There are three paths a, b and c of a projectile projected from point P as shown in (Fig. 5.62). Prove that $v_1 > v_2$ and $v_3 = v_4$.

Which path is correct ?



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Exercise 5.3

1. A river 400 m wide is flowing at a rate of 2.0 m/s. A boat is sailing at a velocity of 10 m/s wilth respect to the water, in a direction perpendicular toteh river.a. Find the time taken by the boat to reach the opposite bank. b. How far from the point directly opposite to the starting point does tbhe boad reach the opposite bank?

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2. A ,man wishing to cross a river flowing with velocity u jumps at an angle θ with the river flow.

(a) Find the net velocity of the man with respect to ground if he can swim with speed v in still water.

(b) In what direction does the boat actually move ?

(c) Find how far from the point directly opposite to the starting point does the boat reach the opposite bank, if the width of the river is d.

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3. Find the time an aeroplane having velocity v takes to fly around a square with side a if the wind is blowing at a velocity u along one side of the square.\

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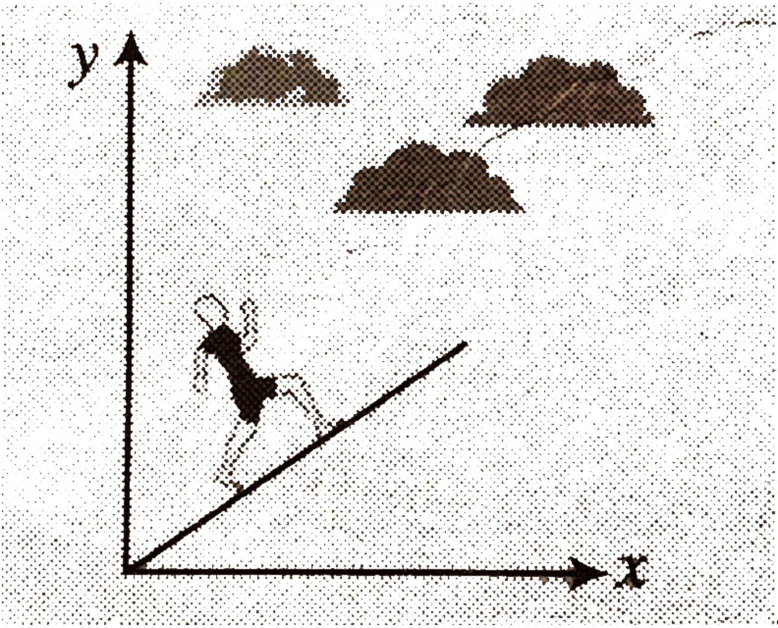
4. To a man running upwards on the hill, the rain appears to fall vertically downwards with $4ms^{-1}$. The velocity vector of the man w.r.t. earth is $\left(2\hat{i}+3\hat{j}\right)ms^{-1}$. If the man starts running down the hill with the same speed, then determine the relative speed of the rain w.r.t. man.



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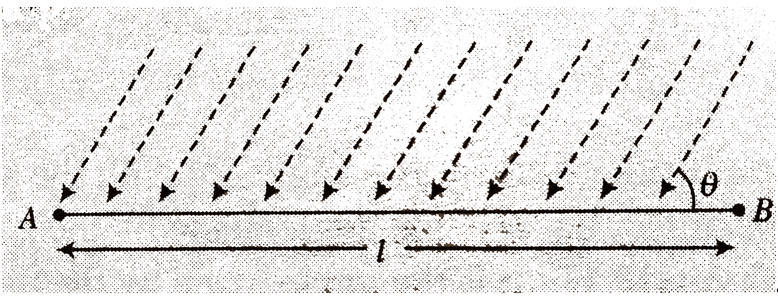
5. An aeroplane flies along a straight path A and B and returns back again. The distance between A and B is l and the aeroplane maintains the constant speed v w.r.t. wind.

There is a steady wind with a speed u at an angle θ with line AB. Determine the expression for the total time of the trip.



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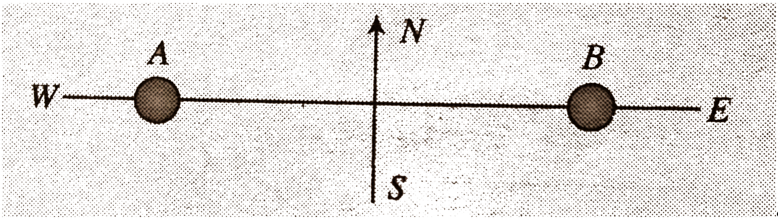
6. A pilot is supposed to fly a certain distance AB, due east from $A \rightarrow B$ and then due west from $B \rightarrow A$. The velocity of plane is v and that of air is u. The time for the round trip is t_0 in still air. Show that

(a) if the air velocity be due east or west, the time for round trip will be $t_1 = \dfrac{t_0}{\left(1 - \frac{u^2}{v^2}\right)}$.

(b) if the air velocity is due north or south, the time for a round trip will be

$$t_2 = \frac{t_0}{\sqrt{\left(1 - \frac{u^2}{v^2}\right)}}.$$



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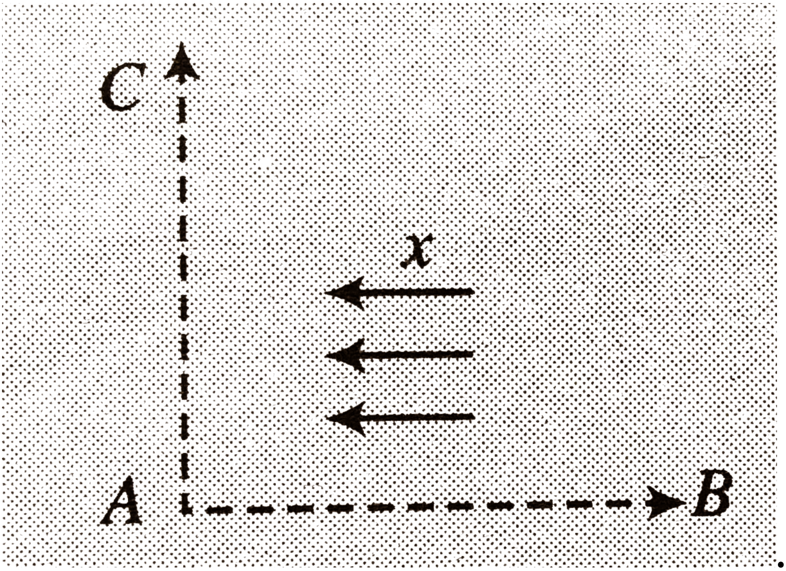
7. Wind blows with a velocity x in the direction shown in (Fig. 5.137). Two aeropalnes starts out from point A and fly with a constant speed y. The first flies from $A \rightarrow B$ and the other $A \rightarrow C$. Both of them return back to A. If

$AB = AC$, then which plane will return to point A first, and what be the ratio of the times of flight of the two planes ?



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8. Two ships A and B are $10km$ apart on a line running south to north. Ship A farther north is streaming west at $20km/h$ and ship B is streaming north at $20km/h$. What is their distance of closest approach and how long do they take to reach it?

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9. A boatman finds that he can save $6s$ in crossing a river by the quickest path than by the shortest path. If the velocity of the boat and the river be, respectively, $17ms^{-1}$ and $8ms^{-1}$, find the river width.

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10. A man directly crosses a river in time t_1 and swims down the current a distance equal to the width of the river I time t_2. If u and v be the speed of the current and the man respectively, show that : $t_1 : t_2 = \sqrt{v+u} : \sqrt{v-u}$).

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11. A person rows a boat across a river making an anglen of 60° with the downstream. Find the percentage time he would have saved, ahd he crossed the river in the shortest possible time.

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12. A person rows a boat across a river making an angle of 60° with the downstream. Find the percentage time he would have saved, and he crossed the river in the shortest possible time.

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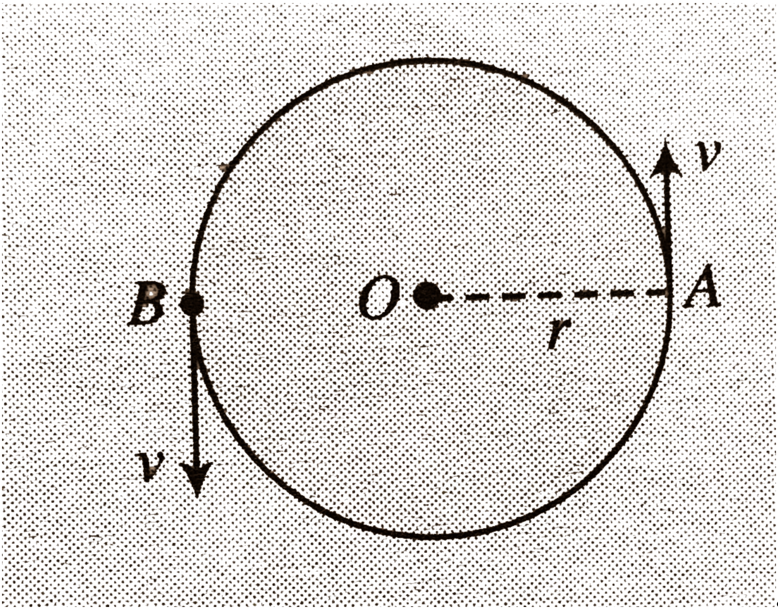
Exercise 5.4

1. Particles A and B move with constant and equal speeds in a circle as shown in (Fig. 5.164). Find the angular velocity of the particle A with respect to B, if the angular velocity of particle

$A w.r.t. O$ is ω.



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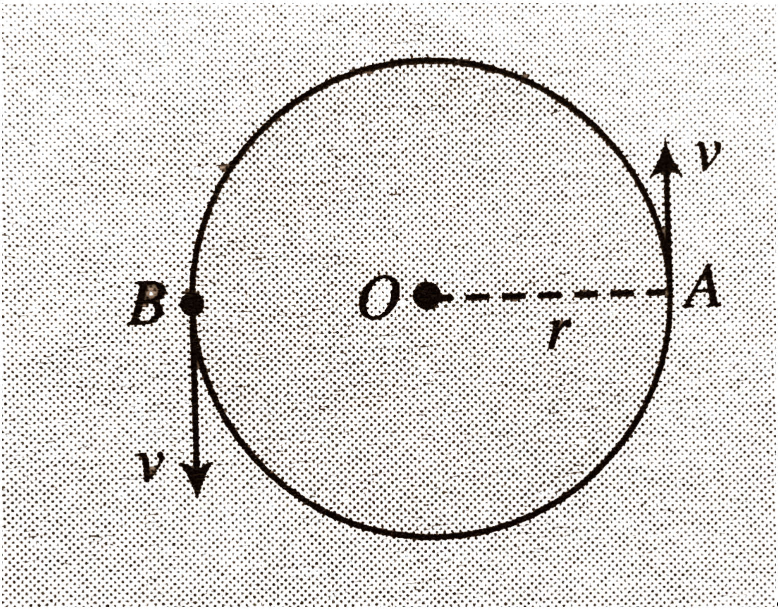
2. Particles A and B move with constant and equal speeds in a circle as shown in (Fig. 5.164). Find the angular velocity of the particle A with respect to B, if the angular velocity of particle $A w. r. t. O$ is ω.



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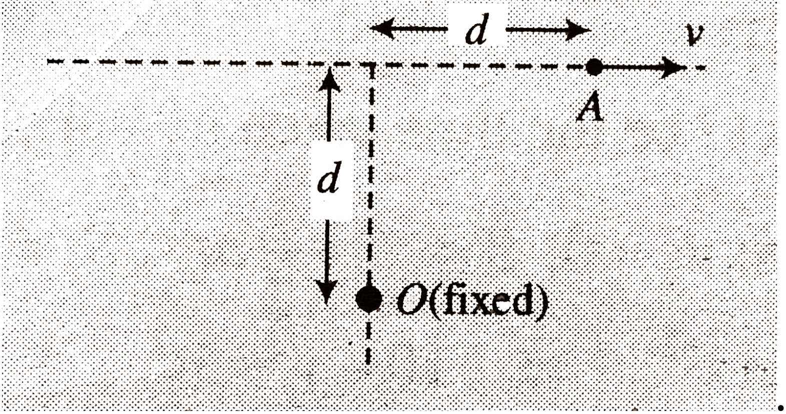
3. Find the angular velocity of A with respect to O at the instant shown in (Fig. 5.165).



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4. A particle travels in a circle of radius 20 cm at a speed thast uniformly increases. If the speed changes from 5.0 m/s to 6.0 m/s in 2.0s, find the angular aceleration.

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5. Find the magnitude of the linear acceleration of a particle moving in a circle of radius 10 cm with uniform speed completing the circle in 4s.

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6. A particle in a circular path speeds up with a uniform rate between two diametrically opposite points of a circle of radius R. If its time of motion between these two points is equal to T, find the accelertaion of the particle averaged over the time T.

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7. The linear speed of a particle moving in a circle of radius R varies with time as $v = v_0 - kt$, where k is a positive constant. At what time the magnitudes of angular velocity and angular acceleration will be equal ?

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8. A particle at the edge of a ratating disc speeds up at a uniform angular acceleration $\propto$. If the radius of the disc is R, find the angular distance covered by the particle till its acquires a total acceleration a_0.

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9. The angular velocity of a particle moving in a circle realative to the center of the circle is equal to ω. Find the angular velocity of the particle relative to a point on the circular path.

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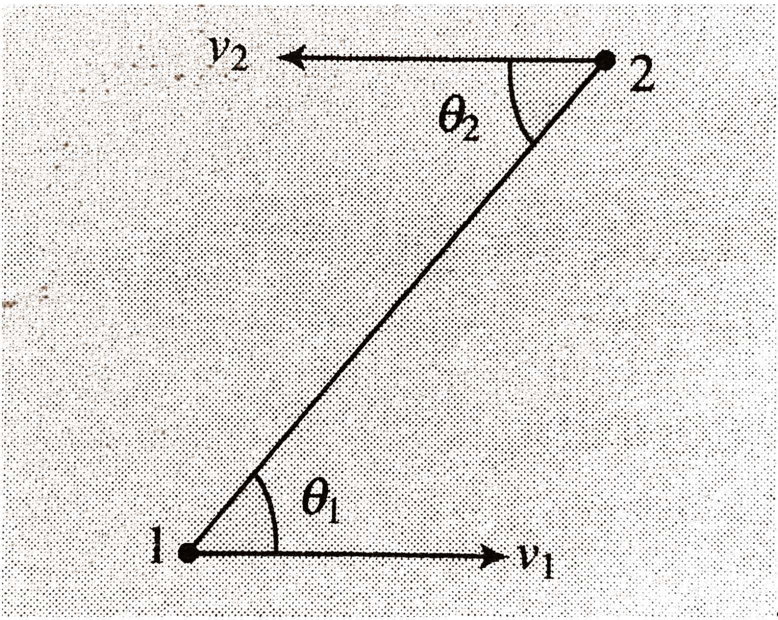
10. Two particles 1 and 2 move with velocities $\overrightarrow{v}_1$ and $\overrightarrow{v}_2$ making the angles θ_1 and θ_2 with the line joining them, respectively. Find angular velocity of $relative \rightarrow 1$.



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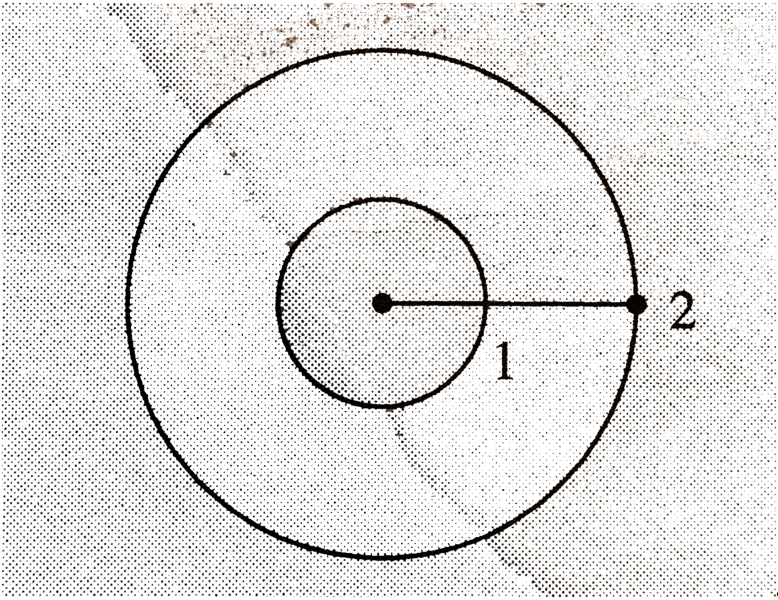
11. Two satellities 1 and 2 orbiting with the time periods T_1 and T_2, respectively, lie on the same line as shown in (Fig. 5.167). After what minimum time, again the satellities will remain on the same line ? Assume that the two satellities should lie in same side of the center of their concentric circular paths.



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Exercise Subjective

1. Two particles were projected one by one with the same initial velocity from the same point on level ground. They follow the same parabolic trajectory and are found to be in the same horizontal level, separated by a distance of $1m, 2s$ after the second partice was projected. Assume that the horizontal component of their velocities is $0.5ms^{-1}$. Find

(a) the horizontal range of the parabolic path.

(b) the maximum height for the parabolic path.

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2. A particle is projected from a point on the level ground and its height is h when at horizontal distances a and $2a$ from its point of projection. Find the velocity of projection.

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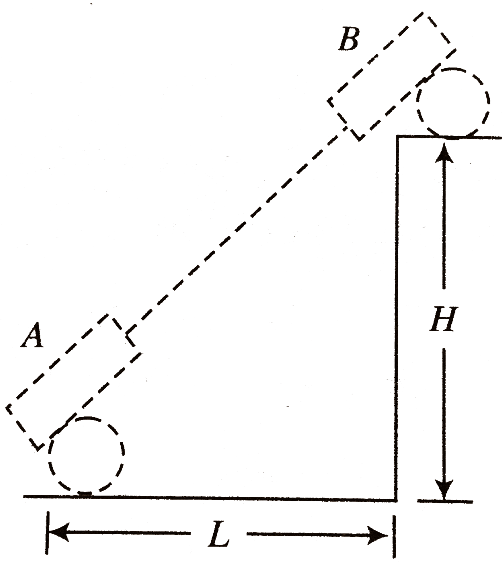
3. Cannon A is located on a plain a distance L from a wall of height H. On top of this wall is an idential cannon (cannon B). Ignore air resistance throughout this problem.

Also ignore the size of the cannons relative to L and H. The two groups of gunners aim the cannons directly at each other. They fire at each other simultaneously, with equal muzzle speed v_0

What is the velue of v_0 for which the two cannon balls collide just as they hit the ground ?



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4. A platform is moving upwards with a constant acceleration of $2ms^{-2}$. At time $t = 0$, a boy standing on the platform throws a ball upwards with a relative speed of $8ms^{-1}$. At this instant, platform was at the height of $4m$ from the ground and was moving with a speed of $2ms^{-1}$. Take $g = 0ms^{-2}$. Find

(a) when and where the ball strikes the platform.

(b) the maximum height attained by the ball from the ground.

(c) the maximum distance of the ball from the platform.

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5. A stone is projected from the ground in such a direction so as to hit a bird on the top of a telegraph post of height h and attains the maximum height of 2h above the ground. If at the insatant of projection, the bird were to fly away horizontally with a uniform speed, find the ratio between the horizontal velocity of bird and the horizontal component of velocity of stone, if the stone hits the bird while descending.

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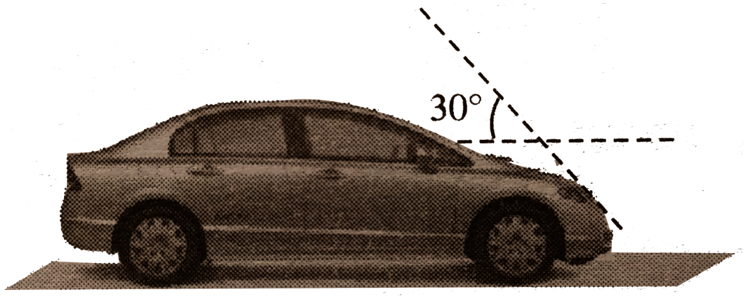
6. A projectile is fired with velocity v_0 from a gun adjusted for a maximum range. It passes through two points P and Q whose heights above the horizontal are h each. Show that the separation of the two points is $\frac{v_0}{g}\sqrt{v_0^2 - 4gh}\Big)$.

Watch Video Solution

7. Hailstones falling vertically with a speed of $10ms^{-1}$, hit the wind screen (wind screen makes an angle 30° with the horizontal) of a moving car and rebound elastically. Find the velocity of the car if the driver finds the hailstones rebound vertically after striking.



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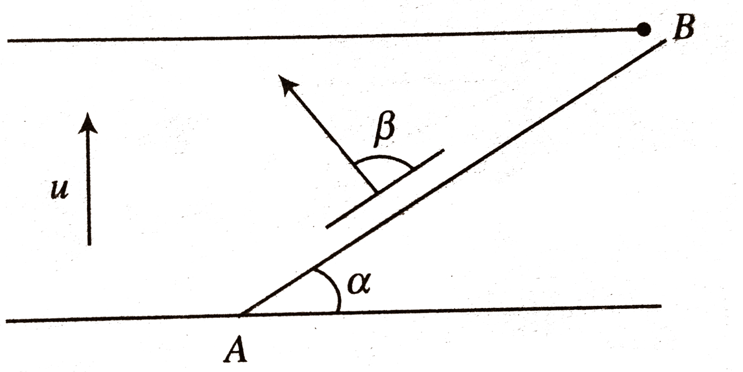
8. A launch travels across a river from a point A to a point B of the opposite bank along the line AB forming angle $\propto$ with the bank. The flag on the mast of the launch makes an angle β with its direction of motion. Determine the speed of the launch w.r.t. the bank. The velocity of wind is u perpendicular to the stream.



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9. An airplane is observed by two observers traveling at $60 km h^{-1}$ in two vehicles moving in opposite directions on a straight road. To an observer in one vehicle, the plane appears to cross the road track at right angles while to the other appears to be 45°. At what angle does the plane actually cross the road track and what is its speed relative to ground ?

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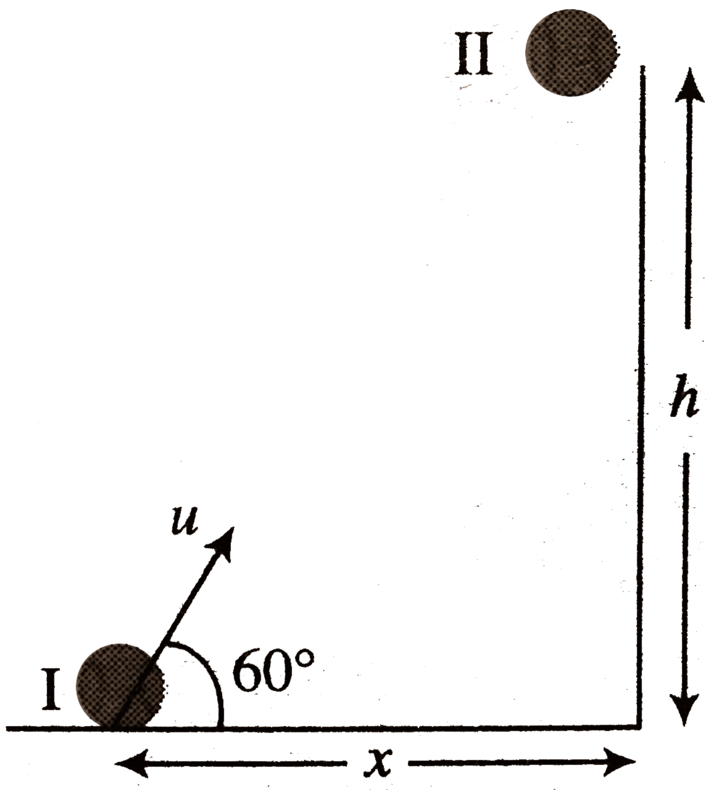
10. Ball I is thrown towards a tower at an angle of 60° with the horizontal with unknown speed (u). At the same moment, ball

II is released from the top of tower as shown in (Fig. 5.189). Balls collide after $2s$ and at the moment of collision, the velocity of ball I is horizontal. Find the

(a) speed u

(b) distance of point of projection of ball I from base of tower (x)

(c) height of tower



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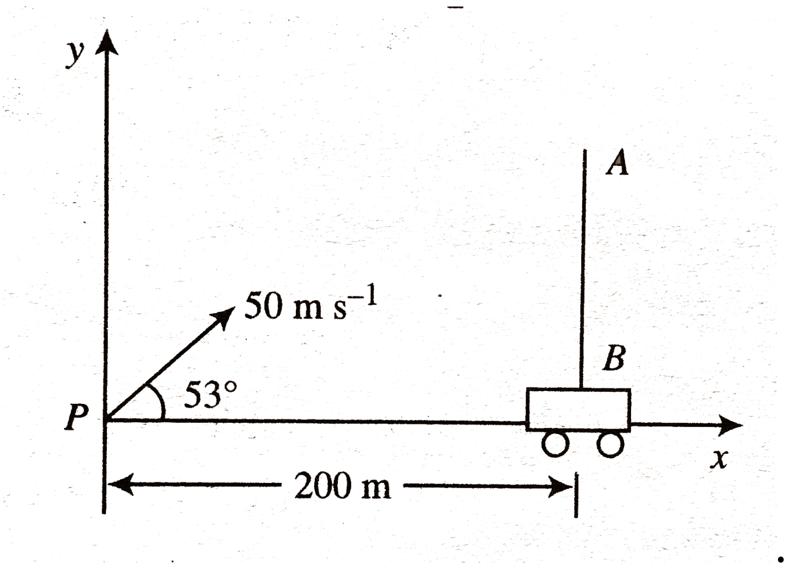
11. A ball is fired from point P, with an initial speed of $50ms^{-1}$ at an angle of 53°, with the horizontal. At the same time, a long wall $ABat200m$ from point P starts moving toward P with a constant speed of $10ms^{-1}$.

Find

(a) the time when the ball collides with wall AB.

(b) the coordinate of point C, where the ball xollides, taking point P as origin.



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12. A rock is launched upward at 45°. A bee moves along the trajectory of the rock. What is the magnitude of acceleration $\left(\text{in} ms^{-2}\right)$ of the bee at the top point of the trajectory ? For the rock, neglect the air resistance.

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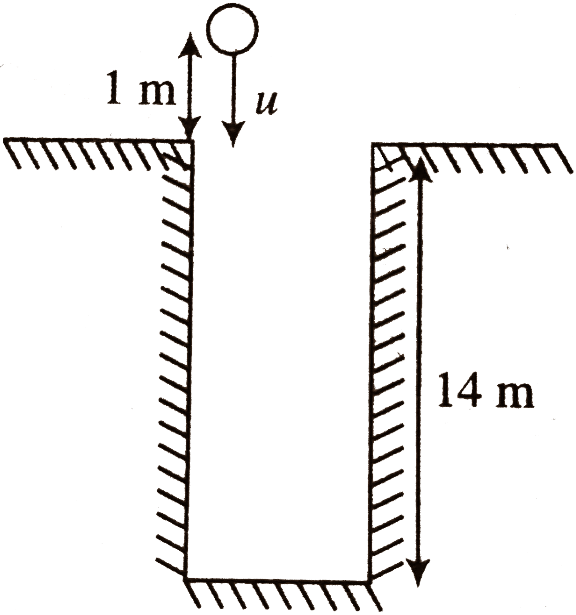
13. A boy throws a ball with speed u in a well of depth $14m$ as shown in (Fig. 5.191). On bounce with the bottom of the well, the speed of the ball gets halved. What should be the minimum value of $u\left(\text{in} ms^{-1}\right)$ such that the ball may be able to reach his hands again ? It is given that his hands are at $1m$ height from top of the well while throwing and catching.



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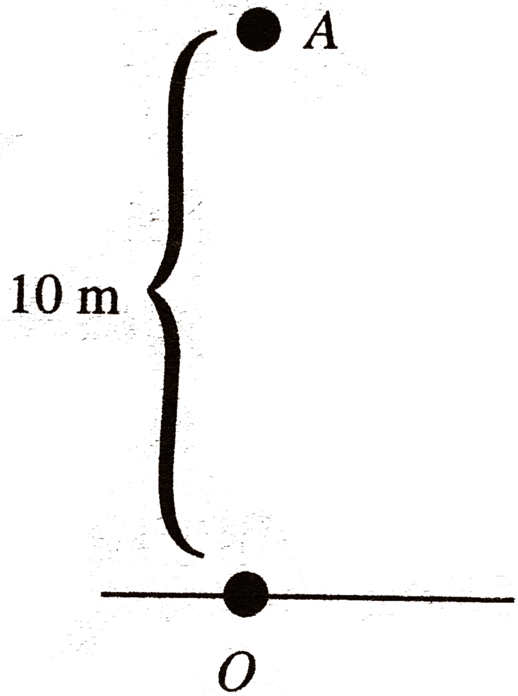
14. A helicopter is moving verticallly upwards with a velocity $5ms^{-1}$. When the helicopter is at a height $10m$ from ground, a stone is thrown with a velocity $\left(3\hat{i}+4\hat{j}\right)ms^{-1}$ from the helicopter w.r.t. the man in it. Considering the point on ground vertically below the helicopter as the origin of coordinates, and the ground below as xy plane, find the coordinates of the point where the stone will fall, its distance from origin at the instant the stone strikes the ground, assuming helicopter moves upwards with constant velocity.



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15. The direction of a projectile at a certain instant is inclined at an angle $\propto$ to the horizontal , after t second, it is inclined at an angle β. Prove that the horizontal component of the velocity of the projectile is $\frac{\text{gt}}{\tan\propto - \tan\beta}$.

Watch Video Solution

16. A boy on a train of height h_1 projects a coin his friend of height h_2 standing on the

same train, with a velocity v relative to the train, at an angle θ with horizontal. If the train moves with a constant velocity v' in the direction of x - motion of the coin, find the

(a) distance between the boys so that the second boy can catch the coin,

(b) maximum height attained by the coin, and

(c) speed with which the second boy catches the coin relative to himself (train) and ground.

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17. To a man going with a speed of $5ms^{-1}$, rain appears to be falling vertically. If the actual speed of rain is $10ms^{-1}$, then what is the angle made by rain with the vertical ?

Watch Video Solution

18. A ship is sailing due north at a speed of $1.25ms^{-1}$. The current is taking it towards east at the rate of $2ms^{-1}$. and a sailor is climbing a vertical pole in the ship at the rate

of $0.25ms^{-1}$. Find the magnitude of the velocity of the sailor with respect to ground.

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19. A bomber plane moves due east at $100kmh^{-1}$ over a town T at a certain instant of time. Six minutes later, an interceptor plane sets off flying due north - east from the station S which is $40km$ south of T. If both maintain their courses, find the velocity with which the interceptor plane must fly in order to just overtake the bomber.

Watch Video Solution

20. The velocity if a swimmer (v) in stil water is less than the velocity of water (u) in a river. Show that the swimmer must aim himself at an angles $\cos^{-1}(v/u)$ with upstream in order to cross the river along the shortest possible path. Find thr drifting (distance moved along the direction of stream in crossing the river) of the swimmer along this shortest possible path.

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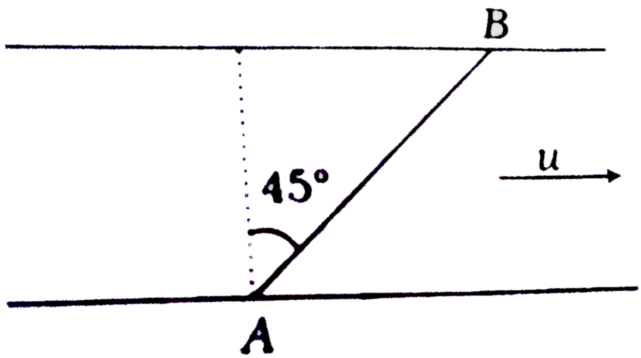
21. A man wants to reach point B on the opposite bank of a river flowing at a speed as shown in figure. What minimum speed and in which direction should the man swim relative to water so that he can reach point B ?



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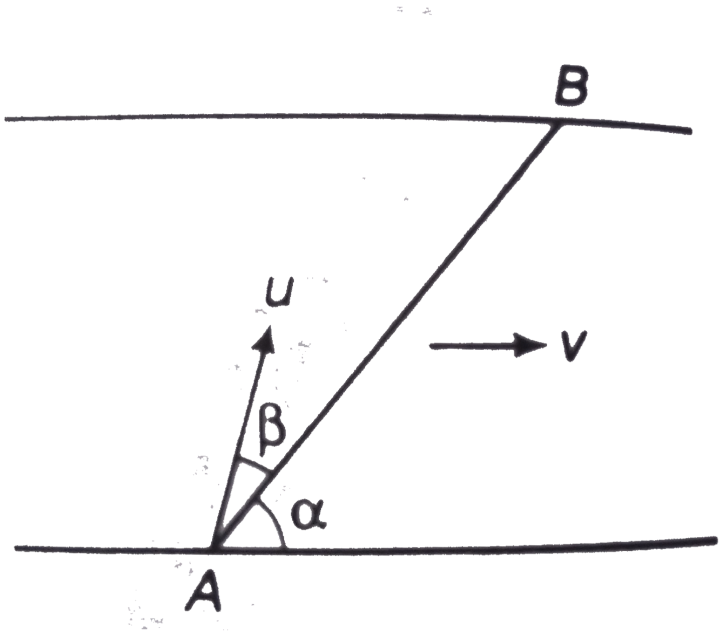
22. A launch plies between two points A and B on the opposite banks of a river always following the line AB. The distance S between points and B is 1200 m. The velocity of the river current $v = 1.9 m / s$ is constant over the entire width of the river. The line AB makes an angle $\alpha=60^{\circ}$ with the direction of the current. With what velocity u and at what angle beta to the line AB should the launch move to cover the distance AB and back in a time $t=5 \mathrm{~min}$? The angle beta remains the same during the passage from A to B and from

B to A.



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23. A ship A streams due north at $16 km h^{-1}$ and a ship B due west at $12 km h^{-1}$. At a certain instant B is $10 km$ north east of A. Find the

(a) magnitude of velocity of $A relative \rightarrow B$.

(b) nearest distance of approach of ships.

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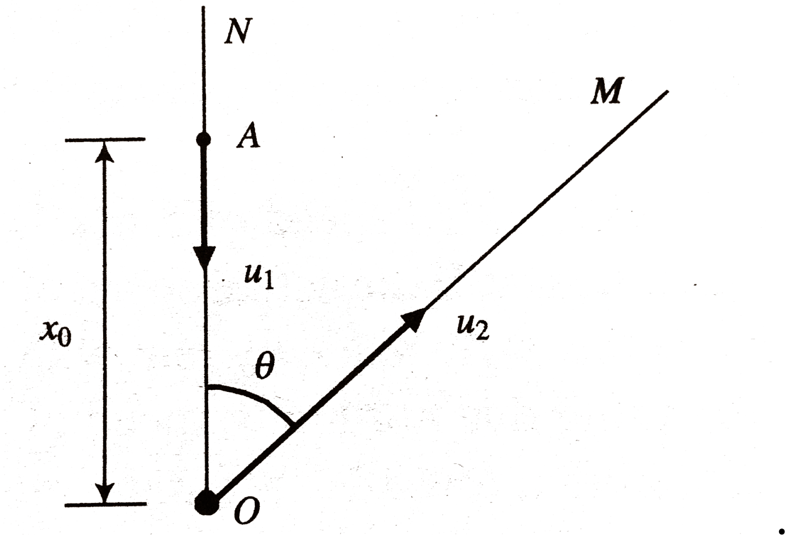
24. Two particles start moving simultaneously with constant velocities u_1 and u_2 as shown in (Fig. 5.194). First particle starts from A along AO and second starts from O along OM. Find the shortest distance between them during their motion.



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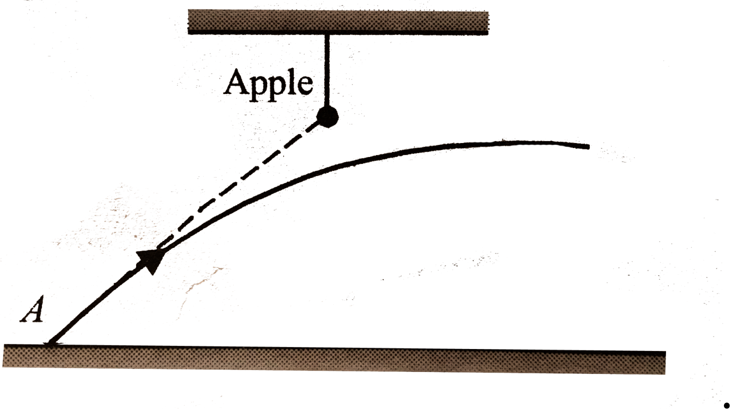
25. The front wind screen of a car is inclined at an 60° with the vertical. Hailstones fall vertically downwards with a speed of

$5\sqrt{3}ms^{-1}$. Find the speed of the car so that hailstones are bounced back by the screen in vertically upward direction with respect to car. Assume elastic collision of hailstones with wind screen.

Watch Video Solution

26. A particle is projected from point A to hit an apple as shown in (Fig. 5.195). The particle is directly aimed at the apple. Show that particle will not hit the apple. Now show that if the string with which the apple is hung is cut at the time of firing the particle, then the particle will hit the apple.



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27. A ball is projected for maximum range with speed $20ms^{-1}$. A boy is located at a distance

$25m$ from point of throwing start run to catch the ball at the time when the ball was projected. Find the speed of the boy so that he can catch the ball $(Take g = 10ms^{-1})$.

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28. A target is fixed on the top of a tower $13m$ high. A person standing at a distance of $50m$ from the pole is capable of projecting a stone with a velocity $10\sqrt{g}ms^{-1}$. If he wants to strike the target in shortest possible time, at what angle should he project the stone ?

Watch Video Solution

29. A stone is projected from the ground in such a direction so as to hit a bird on the top of a telegraph post of height h and attains the maximum height of 2h above the ground. If at the insatant of projection, the bird were to fly away horizontally with a uniform speed, find the ratio between the horizontal velocity of bird and the horizontal component of velocity of stone, if the stone hits the bird while descending.

Watch Video Solution

30. A ball rolls of the top fi a strair way with horizonntal velocity of magnitude $1.8ms^{-1}$. The steps are $0.20m$ high and $0.02m$ wide , Which step will the ball it first ? (g = 10 m//s^@)`.

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31. A machine gun is mounted on the top of a tower of height h. At what angle should the gun be inclined to cover a maximum range of firing on the ground below ? The muzzle speed of bullet is $150ms^{-1}$. Take $g = 10ms^{-2}$.

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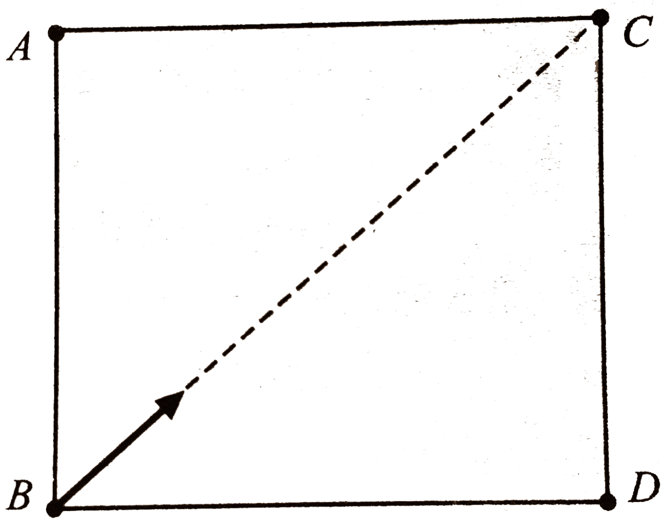
32. (Figure 5.196) shows an elevator cabin, which is moving downwards with constant acceleration a . A particle is projected from corner A, directly towards diagonally opposite corner C. Then prove that

(a) particle will hit C only when $a = g$.

(b) Particle will hit the wall CD if $a < g$.

(c) Particle will hit the roof BC if $a > g$.



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33. A ball is thrown with a velocity whose horizontal component is $12ms^{-1}$ from a point $15m$ above the ground and $6m$ away from a verticlewall $18.75m$ high in such a way so as just to clear the wall. At what time will it reach the ground ? $(g = 10ms^{-2})$.

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34. A particle is projected up an inclined plane of inclination β at na elevation $\propto$ to the horizon. Show that $\tan \propto = \cot \beta + 2\tan \beta$, if the particle strikes the plane at right angles

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35. Two parallel straight lines are inclined to the horizon at an angle $\propto$. A particle is projected from a point mid way between them so as to graze one of the lines and strikes the other at right angle. Show that if θ is the angle between the direction of projection and either of lines, then $\tan \theta = \left(\sqrt{2-1}\right)\cot \propto$.

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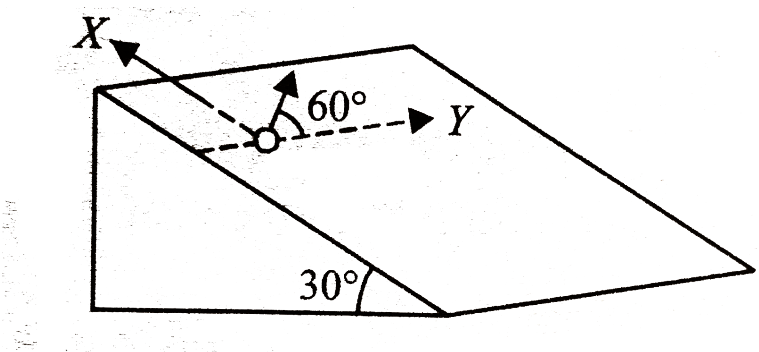
36. A small sphere is projected with a velocity of $3ms^{-1}$ in a direction 60° from the horizontal y - axis, on the smooth inclined plane (Fig. 5.197). The motion of sphere takes place in the x - y plane. Calculate the magnitude v of its velocity after $2s$.



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37. A gun is fired from a moving platform and ranges of the shot are observed to be R_1 and R_2 when the platform is moving forwards and backwards, respectively, with velocity v_P. Find the elevation of the gun $\propto$ in terms of the given quantities.

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38. A cylclist is riding with a speed of $27kmh^{-1}$. As he approaches a circular turn on the road of radius $80m$, he applies brakes and reduces his speed at the constant rate of $0.5ms^{-2}$. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn ?

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39. An electric fan has blades of length $30cm$ as measured from the axis of rotation. If the fan is rotating at 1200 rpm, find the acceleration of a point on the tip of a blade.

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40. A particle starts from rest and moves in a circular motion with constant angular acceleration of $2rads^{-2}$. Find

(a) Angular velocity

(b) Angular displacement of the particle after $4s$.

(c) The number of revolutions completed by the particle during these $4s$.

(d) If the radius of the circle is $10cm$, find the magnitude and direction of net acceleration of the particle at the end of $4s$.

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Exercise Single Correct

1. Rain is falling vertically downwards with a speed of $4 km h^{-1}$. A girl moves on a straight road with a velocity of $3 km h^{-1}$. The apparent velocity of rain with respect to the girl is.

A. $3 km h^{-1}$

B. $4 km h^{-1}$

C. 5 km h^-1`

D. $7 km h^{-1}$

Answer: C

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2. Ship A is travelling with a velocity of $5kmh^{-1}$ due east. A second ship is heading 30° east of north. What should be the speed of second ship if it is to remain always due north with respect to the first ship ?

A. a. $10kmh^{-1}$

B. b. $9kmh^{-1}$

C. c. $8kmh^{-1}$

D. d. $7kmh^{-1}$

Answer: A

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3. A man swims from a point A on the bank of a river if width $100m$. When he swims perpendicular to the water current, he reaches the other bank $50m$ downstream. The angle to the bank at which he should swim, to reach the directly opposite point B on the other bank is.

.

A. 10° upstream

B. 20° upstream

C. 30° upstream

D. 60° upstream

Answer: D

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4. Rain is falling vertically with a velocity of $25ms^{-1}$. A woman rides a bicycle with a speed of $10ms^{-1}$ in the north to south direction.

What is the direction (angle with vertical) in which she should hold her umbrella to safe herself from rain ?

A. a. $\tan^{-1}(0.4)$

B. b. $\tan^{-1}(1)$

C. c. $\tan^{-1}(\sqrt{3})$

D. d. $\tan^{-1}(2.6)$

Answer: A

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5. A police van moving on a highway with a speed of $30kmh^{-1}$ fires a bullet at a thief's car speeding away in the same direction with a speed of $192kmh^{-1}$. If the muzzle speed of the bullet is $150ms^{-1}$, with what speed does the bullet hit the thief's car?

A. $120ms^{-1}$

B. $90ms^{-1}$

C. $125ms^{-1}$

D. $105ms^{-1}$

Answer: D

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6. A bird is flying towards north with a velocity $40kmh^{-1}$ and a train is moving with velocity $40kmh^{-1}$ towards east. What is the velocity of the bird boted by a man in the train ?

A. $40\sqrt{2}kmh^{-1}N-E$

B. $40\sqrt{2}kmh^{-1}S-E$

C. $40\sqrt{2}kmh^{-1}N-W$

D. $40\sqrt{2}kmh^{-1}S-W$

Answer: C

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7. A river is flowing from west to east at a speed of 5 metres 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. $\tan^{-1}(2) E of N$

B. $\tan^{-1}(2) N of E$

C. $30^{\circ} E of N$

D. $60^{\circ} E of N$

Answer: B

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8. A boat is moving with a velocity $3\hat{i} + 4\hat{j}$ with respect to ground. The water in the river is moving with a velocity $-3\hat{i} - 4\hat{j}$ with respect to ground. The relative velocity of the boat with respect to water is.

A. $8\hat{j}$

B. $-6\hat{i}-8\hat{j}$

C. $6\hat{i}+8\hat{j}$

D. $5\sqrt{2})$

Answer: C

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9. A car is moving towards east with a speed of $25 km h^{-1}$. To the driver of the car, a bus appears to move towards north with a speed of $25\sqrt{3} km h^{-1}$. What is the actual velocity of the bus ?

A. $50 km h^{-1}, 30^{\circ} E of N$

B. $50 km h^{-1}, 30^{\circ} N of E$

C. $25 km h^{-1}, 30^{\circ} E of N$

D. $25 km h^{-1}, 30^{\circ} N of E$

Answer: A

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10. A swimmer wishes to cross a $500-m$ river flowing at $5kmh^{-1}$. His speed with respect to water is $3kmh^{-1}$. The shortest possible time to cross the river is.

A. 10 min

B. 20 min

C. 6 min

D. 7.5 min

Answer: A

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11. A train of $150m$ length is going towards North direction at a speed of $10m/s$. A parrot flies at the speed of $5m/s$ towards South direction parallel to the railways track. The time taken by the parrot to cross the train is

A. $12s$

B. $8s$

C. $15s$

D. $10s$

Answer: D

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12. A man can swim in still water with a speed of $2ms^{-1}$. If he wants to cross a river of water current speed $\sqrt{3}ms^{-1}$ along the shortest possible path, then in which direction should he swim ?

A. a. At an angle 120° to the water current.

B. b. At an angle 150° to the water current.

C. c. At an angle 90° to the water current.

D. d. None of these

Answer: B

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13. A truck is moving with a constant velocity of $54kmh^{-1}$. In which direction (angle with the direction of motion of truck) should a stone be projected up with a velocity of $20ms^{-1}$, from the floor of the truck of the truck, so as to appear at right angles to the truck, for a person standing on earth ?

A. $\cos^{-1}\left(-\frac{3}{4}\right)$

B. $\cos^{-1}\left(-\frac{1}{4}\right)$

C. $\cos^{-1}\left(-\frac{2}{4}\right)$

D. $\cos^{-1}\left(\frac{3}{4}\right)$

Answer: A

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14. A river flows with a speed more than the maximum speed with which a person can swim in still water. He intends to cross the river by the shortest possible path (i.e., he wants to reach the point on the opposite bank which directly opposite to the starting point). Which of the following is correct ?

A. He should normal to the river bank.

B. He should start in such a way that he moves normal to the bank, relative to the bank.

C. He should start in a particular (calculated) direction making an obtuse angle with the direction of water current.

D. The man cannot cross the river in that way.

Answer: D

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15. Rain, driven by the wind, falls on a railway compartment with a velocity of $20ms^{-1}$, at an angle of 30° to the vertical. The train moves, along the direction of wind flow, at a speed of $108kmh^{-1}$. Determine the apparent velocity of rain for a person sitting in the train.

A. $20\sqrt{7}ms^{-1}$

B. $10\sqrt{7}ms^{-1}$

C. $15\sqrt{7}ms^{-1}$

D. $10\sqrt{7}kmh^{-1}$

Answer: B

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16. The ratio of the distance carried away by the water current, downstream, in crossing a river, by a person, making same angle with downstream and upstream is $2:1$. The ratio of the speed of person to the water current cannot be less than.

A. $1/3$

B. $4/5$

C. $2/5$

D. $4/3$

Answer: A

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17. A particle is moving in a circle of radius r centred at O with constant speed v. What is the change in velocity in moving from $A \text{to} B(\angle AOB = 40^\circ)$?

A. $2v\sin 20^{\circ}$

B. $4v\sin 40^{\circ}$

C. $2v\sin 40^{\circ}$

D. $v\sin 20^{\circ}$

Answer: A

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18. A particle is projected with a velocity v so that its range on a horizontal plane is twice the greatest height attained. If g is acceleration due to gravity, then its range is

A. $\frac{4v^2}{5g}$

B. $\frac{4g}{5v^2}$

C. $\frac{4v^3}{5g^2}$

D. $\frac{4v}{5g^2}$

Answer: A

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19. Find the angle of projection of a projectile for which the horizontal range and maximum height are equal.

A. $\tan^{-1}(1)$

B. $\tan^{-1}(2)$

C. $\tan^{-1}(3)$

D. $\tan^{-1}(4)$

Answer: D

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20. A particle is projected from ground at some angle with the horizontal. Let P be the point at maximum height H. At what height above the point P should the particle be aimed to have range equal to maximum height ?

A. H

B. 2 H

C. H//2

D. 3 H

Answer: A

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21. The height y and the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = (8t - 5t^2)m$ and $x = 6tm$, where t is in seconds. The velocity with which the projectile is projected at $t = 0$ is.

A. $6ms^{-1}$

B. $8ms^{-1}$

C. $10ms^{-1}$

D. $14ms^{-1}$

Answer: C

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22. In the above problem, what is the angle of projection with horizontal ?

A. $\tan^{-1}(1/4)$

B. $\tan^{-1}(4/3)$

C. $\tan^{-1}(3/4)$

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

Answer: B

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23. A shot is fired from a point at a distance of $200m$ from the foot of a tower $100m$ high so that it just passes over it horizontally. The direction of shot with horizontal is.

A. 30°

B. 45°

C. 60°

D. 70°

Answer: B

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24. Two bullets are fired simultaneously, horizontally and with different speeds from the same place. Which bullet will hit the ground first?

A. Slower one

B. Faster one

C. Both will reach simultaneously

D. Cannot be predicted

Answer: C

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25. The maximum height reached by projectile is $4m$. The horizontal range is $12m$. The velocity of projection in ms^{-1} is (g is acceleration due to gravity)

A. $5\sqrt{g/2}$

B. $3\sqrt{g/2}$

C. $\frac{1}{3}\sqrt{g/2}$

D. $\frac{1}{5}\sqrt{g/2}$

Answer: A

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26. A ball thrown by one player reaches the other in $2s$. The maximum height attained by the ball above the point of projection will be about.

A. 2.5 m

B. 5 m

C. 7.5 m

D. 10 m

Answer: B

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27. A projectile has a time of flight T and range R. If the time of flight is doubled, keeping the angle of projection same, what happens to the range ?

A. R//4

B. R//2

C. 2 R

D. 4 R

Answer: D

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28. A ball is thrown from a point with a speed 'v^(0)' at an elevation angle of θ . From the same point and at the same instant , a person starts running with a constant speed $\frac{'v_0'}{2}$ to catch the ball . Will the person be able to catch the ball ? If yes, what should be the angle of projection θ ?

A. $Yes, 60^\circ$

B. $Yes, 30^\circ$

C. No

D. $Yes, 45^\circ$

Answer: A

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29. A body is projected at an angle of 30° with the horizontal and with a speed of $30ms^{-1}$. What is the angle with the horizontal after $1.5s$? $(g = 10ms^{-2})$.

A. 0°

B. 30°

C. 60°

D. 90°

Answer: A

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30. A grasshopper can jump a maximum distance $1.6m$. It spends negligible time on the ground. How far can it go in $10s$?

A. $5\sqrt{2}m$

B. $10\sqrt{2}m$

C. $20\sqrt{2}m$

D. $40\sqrt{2}m$

Answer: C

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31. A body has an initial velocity of $3ms^{-1}$ and has an acceleration of $1ms^{-2}$ normal to the direction of the initial velocity. Then its velocity $4s$ after the start is.

A. $7ms^{-1}$ along the direction of initial velocity.

B. $7ms^{-1}$ along the normal to the direction of initial velocity.

C. $7ms^{-1}$ midway between the two directions.

D. $5ms^{-1}$ at an angle $\tan^{-1}(4/3)$ with the direction of initial velocity.

Answer: D

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32. Two tall buildings are $30m$ apart. The speed with which a ball must be thrown horizontally from a window $150m$ above the ground in one building so that it enters a window $27.5m$ from the ground in the other building is.

A. $2ms^{-1}$

B. $6ms^{-1}$

C. $4ms^{-1}$

D. $8ms^{-1}$

Answer: B

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33. A shell fired from the ground is just able to cross horizontally the top of a wall $90m$ away and $45m$ high. The direction of projection of the shell will be.

A. 25°

B. 30°

C. 60°

D. 45°

Answer: D

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34. Two paper screens A and B are separated by 150m. A bullet pierces A and B. The hole in B in 15 cm below the hole in A. If the bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is: $(g = 10ms^{-2})$

A. $100\sqrt{3}ms^{-1}$

B. $200\sqrt{3}ms^{-1}$

C. $300\sqrt{3}ms^{-1}$

D. $500\sqrt{3}ms^{-1}$

Answer: D

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35. A projectile can have same range R for two angles of projection. It t_1 and t_2 are the times of flight in the two cases, then what is the product of two times of flight ?

A. $t_1t_2 \propto R^2$

B. $t_1t_2 \propto R$

C. $t_1t_2 \propto \frac{1}{R}$

D. $t_1 t_2 \propto \frac{1}{R^2}$

Answer: B

Watch Video Solution

36. A ball is thrown at different angles with the same speed u and from the same points and it has same range in both the cases. If y_1 and y_2 be the heights attained in the two cases, then find the value of $y_1 + y_2$.

A. $\frac{u^2}{g}$

B. $\frac{2u^2}{g}$

C. $\frac{u^2}{2g}$

D. $\frac{u^2}{4g}$

Answer: C

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37. The equation of motion of a projectile is $y = 12x - \frac{3}{4}x^2$. The horizontal component of velocity is $3ms^{-1}$. What is the range of the projectile ?

A. 18 m

B. 16 m

C. 12 m

D. 21.6 m

Answer: B

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38. Two particles are projected from the same point with the same speed u such that they have the same range R, but different maximum heights, h_1 and h_2. Which of the following is correct ?

A. $R = \left(\sqrt{h_1 h_2}\right)$

B. $R = \left(\sqrt{2h_1 h_2}\right)$

C. $R = 2\sqrt{h_1 h_2}\Big)$

D. $R = 4\sqrt{h_1 h_2}\Big)$

Answer: D

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39. At what angle with the horizontal should a ball be thrown so that the range R is related to the time of flight as $R = 5T^2$? $(Take g = 10 m s6 - 2)$.

A. 30°

B. 45°

C. 60°

D. 90°

Answer: B

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40. A ball thrown by one player reaches the other in $2s$. The maximum height attained by the ball above the point of projection will be about.

A. 2.5 m

B. 5 m

C. 7.5 m

D. 10 m

Answer: B

Watch Video Solution

41. A ball rolls off the top of a staircase with a horizontal velocity um/s. If the steps are h meter high and b meter wide, the ball will hit the edge of the nth steps, if:

A. $n = \frac{2hu}{gb^2}$

B. $n = \frac{2hu^2}{gb}$

C. $n = \frac{2hu^2}{gb^2}$

D. $n = \frac{hu^2}{gb^2}$

Answer: C

Watch Video Solution

42. At a height $0.4m$ from the ground the velocity of a projectile in vector form is $\vec{v} = \left(6\hat{i} + 2\hat{j}\right)ms^{-1}$. The angle of projection is

A. 45°

B. 60°

C. 30°

D. $\tan^{-1}(3/4)$

Answer: C

Watch Video Solution

43. A projectile is thrown in the upward direction making an angle of 60° with the horizontal direction with a velocity of

$150ms^{-1}$. Then the time after which its inclination with the horizontal is 45° is

A. $15(\sqrt{3}-1)s$

B. $15(\sqrt{3}+1)s$

C. $7.5(\sqrt{3}-1)s$

D. $7.5(\sqrt{3}+1)s$

Answer: C

Watch Video Solution

44. A gun is firing bullets with velocity v_0 by rotating it through 360° in the horizontal plane. The maximum area covered by the bullets is

A. $\pi\left(\frac{u^2}{g}\right)^2$

B. $\pi\left(\frac{u^2}{2g}\right)^2$

C. $\pi\left(\frac{u}{g}\right)^2$

D. $\pi\left(\frac{u}{2g}\right)^2$

Answer: A

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45. A person sitting in the rear end of the compartment throws a ball towards the front end. The ball follows a parabolic path. The train is moving with uniform velocity of $20ms^{-1}$. A person standing outside on the ground also observers the ball. How will the maximum heights (h_m) attained and the ranges (R) seen by thrower and the outside observer compare each other?

A. Same h_m, differect R

B. same h_m, and R

C. different h_m, same R

D. different h_m, and R

Answer: A

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46. Two stones are projected with the same speed but making different angles with the horizontal. Their horizontal ranges are equal. The angle of projection of one is $\frac{\pi}{3}$ and the maximum height reached by it is 102 m. Then the maximum height reached by the other in metres is

A. $3h_1$

B. $2h_1$

C. $h_1 / 2$

D. $h_1 / 3$

Answer: D

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47. A ball is projected from the ground at angle θ with the horizontal. After $1s$, it is moving at angle 45° with the horizontal and after $2s$ it is moving horizontally. What is the velocity of projection of the ball ?

A. $10\sqrt{3}ms^{-1}$

B. $20\sqrt{3}ms^{-1}$

C. $10\sqrt{5}ms^{-1}$

D. $20\sqrt{2}ms^{-1}$

Answer: C

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48. A body is projected horizontally from the top of a tower with initial velocity $18ms^{-1}$. It hits the ground at angle 45°. What is the vertical component of velocity when it strikes the ground ?

A. $9ms^{-1}$

B. $9\sqrt{2}ms^{-1}$

C. $18ms^{-1}$

D. $18\sqrt{2}ms^{-1}$

Answer: C

Watch Video Solution

49. A plane flying horizontally at $100ms^{-1}$ releases an object which reaches the ground in $10s$. At what angle with horizontal it hits the ground ?

A. 55°

B. 45°

C. 60°

D. 75°

Answer: B

Watch Video Solution

50. A hose lying on the ground shoots a stream of water upward at an angle of 60° to the horizontal with the velocity of $16ms^{-1}$. The height at which the water strikes the wall $8m$ away is.

A. A. 8.9 m

B. B. 10.9 m

C. C. 12.9 m

D. D. 6.9 m

Answer: A

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51. Show that there are two values of time for which a projectile is at the same height. Also show mathematically that the sum of these two times is equal to the time of flight.

A. A. $3T/2$

B. B. $4T/3$

C. C. $3T/4$

D. D. T

Answer: D

Watch Video Solution

52. A golfer standing on level ground hits a ball with a velocity of $52ms^{-1}$ at an angle θ above the horizontal. If $\tan\theta = 5/12$, then find the time for which then ball is atleast $15m$

above the ground $\left(takeg = 10ms^{-2}\right)$.

A. 1 s

B. 2 s

C. 3 s

D. 4 s

Answer: B

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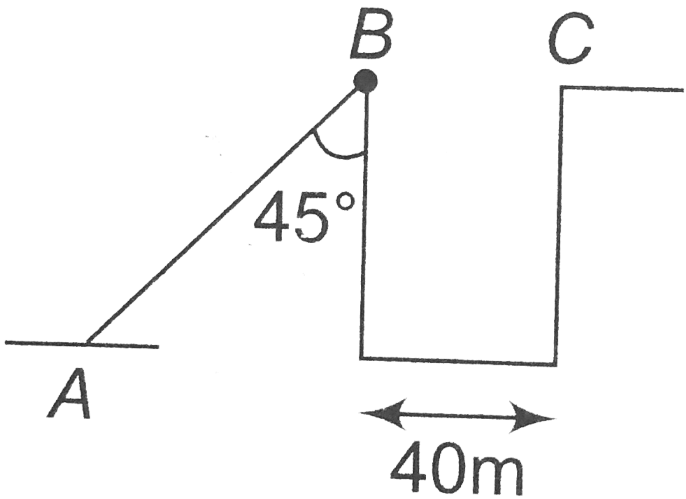
53. A body is projected up a smooth inclined plane with velocity V from the point A as shown in the figure. The angle of inclination is 45° and the top is connected to a well of diameter 40m. If the body just manages to across the well, what is the value of V? Length of inclined plane is $20\sqrt{2}m$.



A. $40ms^{-1}$

B. $40\sqrt{2}ms^{-1}$

C. $20ms^{-1}$

D. $20\sqrt{2}ms^{-1}$

Answer: D

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54. A rifle shoots a bullet with a muzzle velocity of $400ms^{-1}$ at a small target $400m$ away. The height above the target at which the bullet must be aimed to hit the target is $(g = 10ms^{-2})$.

A. 1 m

B. 5 m

C. 10 m

D. 0.5 m

Answer: B

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55. A projectile is fired from level ground at an angle θ above the horizontal. The elevation angle ϕ of the highest point as seen from the launch point is related to θ by the relation.

A. $\tan\phi = 2\tan\theta$

B. $\tan\phi = \tan\theta$

C. $\tan\phi = \frac{1}{2}\tan\theta$

D. $\tan\phi = \frac{1}{4}\tan\theta$

Answer: C

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56. A projectile has initially the same horizontal velocity as it would acquire if it had moved from rest with uniform acceleration of

$3ms^{-2}$ for 0.5 min . If the maximum height reached by it is $80m$, then the angle of projection is $(g = 10ms^{-2})$.

A. $\tan^{-1} 3$

B. $\tan^{-1}(3/2)$

C. $\tan^{-1}(4/9)$

D. $\sin^{-1}(4/9)$

Answer: C

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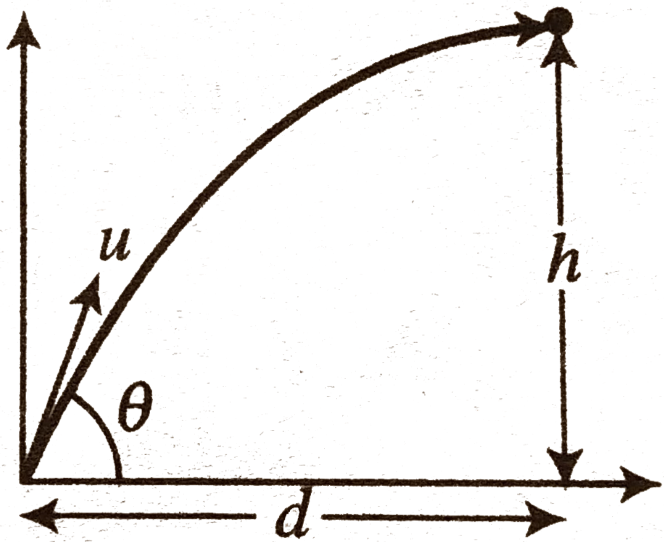
57. If a stone is to hit at a point which is at a distance d away and at a height h (Fig. 5.200) above the point from where the stone starts, then what is the value of initial speed u if the stone is launched at an angle θ ?



A. A. $\frac{g}{\cos\theta}\sqrt{\frac{d}{2(d\tan\theta-h)}}$

B. B. $\frac{d}{\cos\theta}\sqrt{\frac{g}{2(d\tan\theta-h)}}$

C. C. $\sqrt{\frac{gd^2}{h\cos^2\theta}}$

D. D. $\sqrt{\frac{gd^2}{d-h}}$

Answer: B

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58. The speed of a projectile at its maximum height is $\sqrt{3}/2$ times its initial speed. If the range of the projectile is n times the maximum height attained by it, n is equal to :

A. $4/3$

B. $2\sqrt{3}$

C. $4\sqrt{3}$

D. $3/4$

Answer: C

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59. The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where a and b are constant and x and y are, respectively, horizontal and vertical distances of the projectile from the point of projection. The maximum height attained by the particle and the angle of projectile from the horizontal are.

A. $\frac{b^2}{2a}, \tan^{-1}(b)$

B. $\frac{a^2}{b}, \tan^{-1}(2b)$

C. $\frac{a^2}{4b}, \tan^{-1}(a)$

D. $\frac{2a^2}{b}, \tan^{-1}(a)$

Answer: C

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60. A projectile is given an initial velocity of $(\hat{i} + 2\hat{j})m/s$, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical . If $g = 10m/s^2$, the equation of its trajectory is :

A. $y = 2x - 5x^2$

B. $y = x - 5x^2$

C. $4y = 2x - 5x^2$

D. $y = 2x - 25x^2$

Answer: A

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61. Average velocity of a particle in projectile motion between its starting point and the highest point of its trajectory is (projectin speed = u, angle projection from horizontal $=\theta$)

A. $\frac{v}{2}\sqrt{1+2\cos^2\theta}$

B. $\frac{v}{2}\sqrt{1+2\cos^2\theta}$

C. $\frac{v}{2}\sqrt{1+3\cos^2\theta}$

D. $v\cos\theta$

Answer: C

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62. Two balls A and B are thrown with speeds u and $u/2$, respectively. Both the balls cover the same horizontal distance before returning to the plane of projection. If the angle of projection of ball $B is 15^\circ$ with the horizontal, then the angle of projection of A is.

A. $\sin^{-1}\left(\frac{1}{8}\right)$

B. $\frac{1}{2}\sin^{-1}\left(\frac{1}{8}\right)$

C. $\frac{1}{3}\sin^{-1}\left(\frac{1}{8}\right)$

D. $\frac{1}{4}\sin^{-1}\left(\frac{1}{8}\right)$

Answer: B

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63. A body of mass m is projected horizontally with a velocity v from the top of a tower of height h and it reaches the ground at a distance x from the foot of the tower. If a second body of mass $2m$ is projected horizontally from the top of a tower of height $2h$, it reaches the ground at a distance $2x$ from the foot of the tower. The horizontal veloctiy of the second body is.

A. v

B. 2 v

C. $\sqrt{2}v$

D. v//2

Answer: C

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64. A car is moving horizontally along a straight line with a unifrom velocity of $25ms^{-1}$. A projectile is to be fired from this car in such a way that it will return to it after it has moved $100m$. The speed of the projection must be.

A. a. $10ms^{-1}$

B. b.$20ms^{-1}$

C. c.$15ms^{-1}$

D. d. $25ms^{-1}$

Answer: B

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65. The horizontal range and miximum height attained by a projectile are R and H, respectively. If a constant horizontal acceleration $a = g/4$ is imparted to the projectile due to wind, then its horizontal range and maximum height will be

A. $(R+H), \frac{H}{2}$

B. $\left(R+\frac{H}{2}\right), 2H$

C. $(R+2H), H$

D. $(R+H), H$

Answer: D

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66. A particle is projected with a certain velocity at an angle $\propto$ above the horizontal from the foot of an inclined plane of inclination 30°. If the particle strikes the plane normally, then $\propto$ is equal to.

A. $30^\circ + \frac{\tan^{-1}\left(\sqrt{3}\right)}{2}\Big)$

B. 45°

C. 60°

D. $30^{\circ} + \tan^{-1}(2\sqrt{3})$

Answer: A

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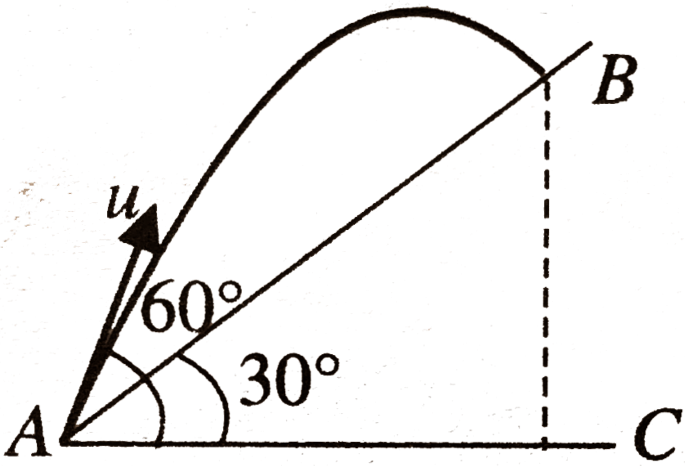
67. In the time taken by the projectile to reach from A to B is t. Then the distance AB is equal to.



A. $\dfrac{ut}{\sqrt{3}}$

B. $\dfrac{\sqrt{3}ut}{2}$

C. $\sqrt{3}ut$

D. $2ut$

Answer: A

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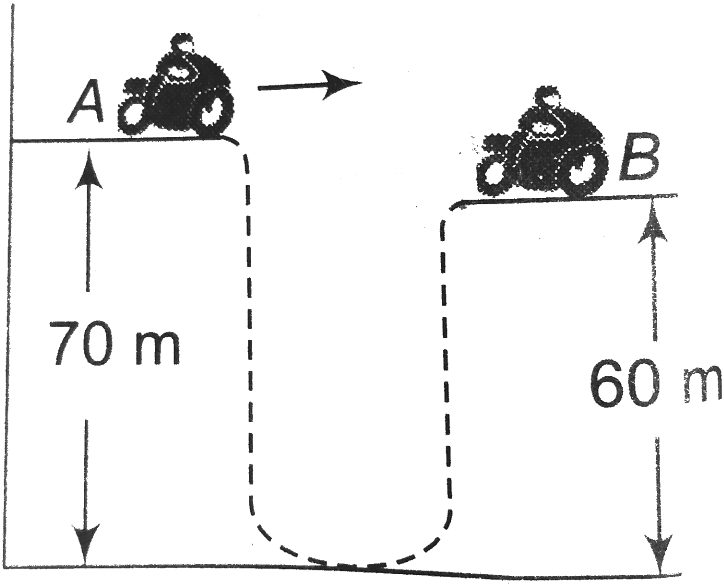
68. A motor cyclist is trying to jump across a path as shown by driving horizontally off a cliff A at a speed of $5ms^{-1}$. Ignore air resistance and take $g = 10ms^{-2}$. The speed with which he touches the peak B is:



A. $20 m s^{-1}$

B. $12 m s^{-1}$

C. $25 m s^{-1}$

D. $15 m s^{-1}$

Answer: D

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69. The height y nad the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = (8t - 5t^2)m$ and $x = 6tm$, where t is in seconds. The velocity with which the projectile is projected at $t = 0$ is.

A. $8ms^{-1}$

B. $6ms^{-1}$

C. $10ms^{-1}$

D. Not obtainable from the data.

Answer: C

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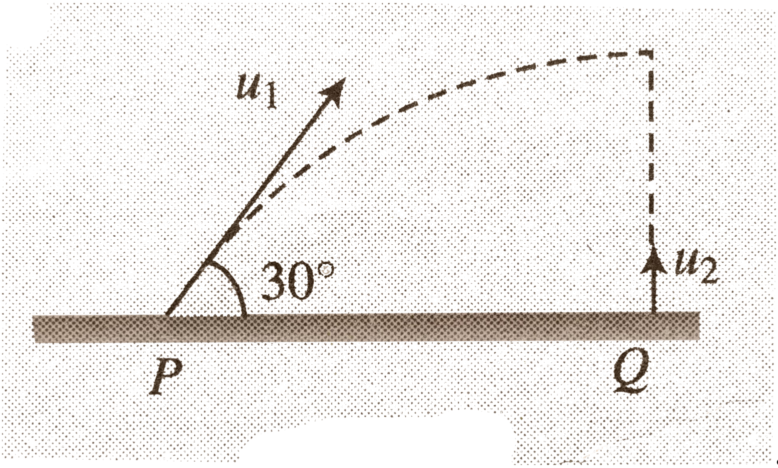
70. A particle P is projected with velocity u_1 at an angle of 30° with the horizontal. Another particle Q is thrown vertically upwards with velocity u_2 from a point vertically below the highest point of path of P. Determine the necessary condition for the two particles to collide at the highest point.



A. 2

B. $\sqrt{\frac{3}{2}}$

C. 0.5

D. 1

Answer: C

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71. A ball is projected from a point A with some velocity at an angle 30° with the horizontal as shown in (Fig. 5.204). Consider a target at point B. The ball will hit the target if it thrown with a velocity v_0 equal to.

.

A. $5ms^{-1}$

B. $6ms^{-1}$

C. $7ms^{-1}$

D. None of these

Answer: D

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72. A body is moving in a circle with a speed of $1ms^{-1}$. This speed increases at a constant rate of $2ms^{-1}$ every second. Assume that the radius of the circle described is $25m$. The total accleration of the body after $2s$ is.

A. $2ms^{-2}$

B. $25ms^{-2}$

C. $\sqrt{5}ms^{-2}$

D. $\sqrt{7}ms^{-2}$

Answer: C

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73. 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 in magnitude

Answer: C

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74. A particle is moving along a circular path with uniform speed. Through what angle does its angular velocity change when it completes half of the circular path ?

A. 0°

B. 45°

C. 180°

D. 360°

Answer: A

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75. 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 $\overrightarrow{\omega}, \overrightarrow{v}, \overrightarrow{\propto}$, and $\overrightarrow{a}_c$. Which of the following relations is not correct ?

A. $\overrightarrow{\omega} \perp \overrightarrow{v}$

B. $\overrightarrow{\omega} \perp \overrightarrow{\propto}$

C. $\overrightarrow{\omega} \perp \overrightarrow{a}_c$

D. $\overrightarrow{v} \perp \overrightarrow{a}_c$.

Answer: B

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76. The angular velocity of a particle moving in a circle of radius $50cm$ is increased in 5 min from 100 revolutions per minute to 400 revolutions per minute. Find the tangential acceleration of the particle.

A. $60ms^{-2}$

B. $\pi / 30ms^{-2}$

C. $\pi / 15ms^{-2}$

D. $\pi / 60ms^{-2}$

Answer: D

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Exercise Multiple Correct

1. A river is flowing towards with a velocity of $5ms^{-1}$. The boat velocity is $10ms^{-1}$. The boat crosses the river by shortest path. Hence,

A. The direction of boat's velocity is 30° west of north.

B. The direction of boat's velocity is north - west.

C. Resultant velocity is $5\sqrt{3}ms^{-1}$.

D. Resultant velocity of boat is $5\sqrt{2}ms^{-1}$.

Answer: A::C

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2. A stationary person observes that rain is falling vertically down at $30 km h^{-1}$. A cyclist is moving up on an inclined plane making an angle 30° with horizontal at $10 km h^{-1}$. In which direction should the cyclist hold his umbrella to prevent himself from the rain ?

A. At an angle $\tan^{-1}\left(\frac{3\sqrt{3}}{5}\right)$ with inclined plane.

B. At an angle $\tan^{-1}\left(\frac{3\sqrt{3}}{5}\right)$ with horizontal.

C. A an angle $\tan^{-1}\left(\frac{\sqrt{3}}{7}\right)$ with inclined plane.

D. At an angle $\tan^{-1}\left(\frac{\sqrt{3}}{7}\right)$ with vertical.

Answer: A::D

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3. Two cities A and B are connected by a regular bus service with buses plying in either direction every T seconds. The speed of each bus is uniform and equal to V_b. A cyclist cycles from $A \to B$ with a uniform speed of V_c. A bus goes past the cyclist in T_1 second in the direction $A \to B$ and every T_2 second in the direction $B \to A$. Then

A. $T_1 = \frac{V_b T}{V_b + V_c}$

B. $T_2 = \frac{V_b T}{V_b - V_c}$

C. $T_1 = \frac{V_b T}{V_b - V_c}$

D. $T_2 = \frac{V_b T}{V_b + V_c}$

Answer: C::D

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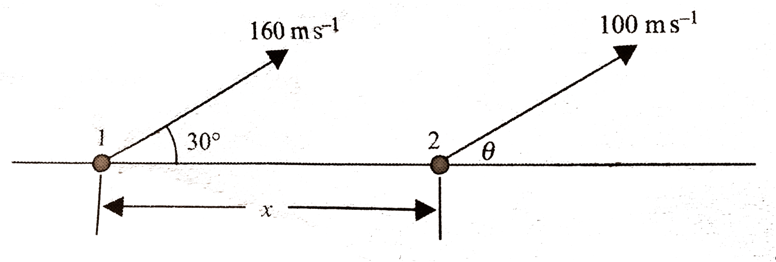
4. Suppose two particles 1 and 2 are projected in vertical plane simultaneously. Their angles of projection are 30° and θ, respectively, with the horizontal. Let they collide after a time$t$ in air. Then



.

A. $\theta = \sin^{-1}(4/5)$ and they will have same speed just before the collision.

B. $\theta = \sin^{-1}(4/5)$ and they will have different speed just before the collision.

C. $x < 1280\sqrt{3} - 960m$.

D. It is possible that the particles collide when both of them are at their highest point.

Answer: C::D

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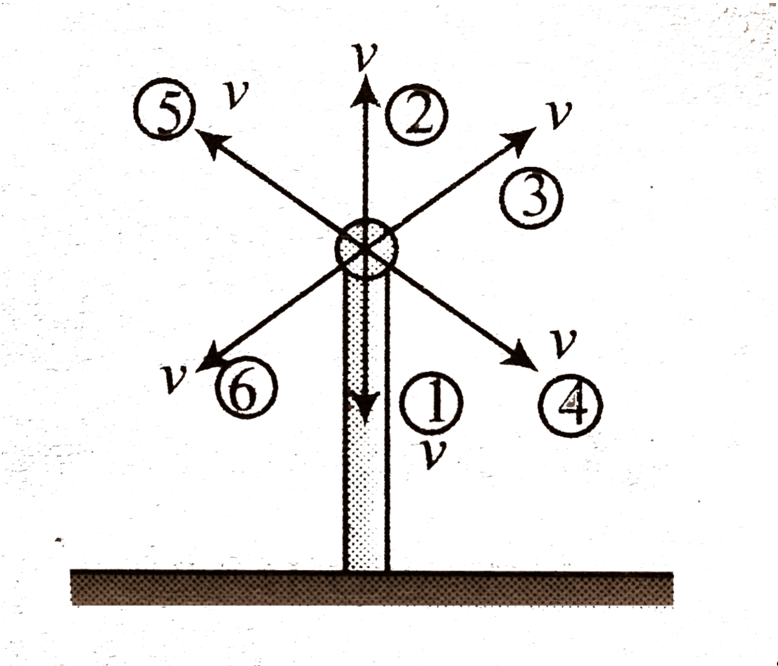
5. All the particles thrown with same initial velocity would strike the ground.



A. with same speed.

B. simultaneously

C. time would be least for the particle thrown with velocity v downward i.e., particle 1.

D. time would be maximum for the particle 2.

Answer: A::C::D

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6. A particle id moving in xy - plane with $y = x/2$ and $v_x = 4 - 2t$. Choose the correct options.

A. Initial velocities in x and y directions are negative.

B. Initial velocities in x and y directions are positive.

C. Motion is first retarded, then accelerated.

D. Motion is first accelerated, then retarded.

Answer: B::C

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7. A heavy particle is projected with a velocity at an angle with the horizontal into the uniform gravitational field. The slope of the trajectory of the particle varies as

A. .

B. .

C. .

D. .

Answer: B::C

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8. A car moves on a circular road. It describes equal angles about the centre in equal intervals of time. Which of the following statement about the velocity of the car is true

A. Velocity is constant

B. Magnitude of velocity is constant but the direction changes.

C. Both magnitude and direction of velocity change.

D. Velocity is directed towards the center of circle.

Answer: A::C::D

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9. A heavy particle is projected with a velocity at an angle with the horizontal into the uniform gravitational field. The slope of the trajectory of the particle varies as

A. .

B. .

C. .

D. .

Answer: B::C::D

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10. A body is projected with velocity u at an angle of projection θ with the horizontal. The direction of velocity of the body makes angle 30° with the horizontal at $t = 2s$ and then after $1s$ it reaches the maximum height. Then

A. a. $u = 20\sqrt{3}ms^{-1}$,

B. b. $\theta = 60^\circ$

C. c. $\theta = 30^{\circ}$

D. d. $u = 10\sqrt{3}ms^{-1}$

Answer: A::B

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11. A particle moves in a circle of radius $20cm$. Its linear speed is given by $v = 2t$ where t is in seconds and v in ms^{-1}. Then

A. The radial acceleration at $t = 2s$ is $80 ms^{-2}$.

B. Tangential acceleration at $t = 2s$ is $2 ms^{-2}$.

C. Net acceleration at $t = 2s$ is greater than $80 ms^{-2}$.

D. Tangential acceleration remains constant in magnitude.

Answer: A::B::C::D

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Exercise Assertion - Reasoning

1. The projectile has only vertical component of velocity at the highest point of its trajectory.

At the highest point, only one component of velocity is present.

A. (a)Statement (I) is true, Statement (II) is true , statement (II) is the correct

explanation for Statement (I).

B. (b)Statement (I) is true, Statement (II) is true , statement (II) is not the correct explanation for Statement (I).

C. (c)Statement (I) is true, Statement (II) is false.

D. (d)Statement (i) is false, Statement (II) is true.

Answer: D

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2. The time of flight of a body becomes n times the original value if its speed is made n times. This due to the range of the projectile which becomes n times.

A. Statement (I) is true, Statement (II) is true , statement (II) is the correct explanation for Statement (I).

B. Statement (I) is true, Statement (II) is true , statement (II) is not the correct

explanation for Statement (I).

C. Statement (I) is true, Statement (II) is false.

D. Statement (i) is false, Statement (II) is true.

Answer: C

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3. If the string of an oscillating simple pendulum is cut, when the bob is at the mean position, the bob falls along a parabolic path. The bob possesses horizontal velocity at the mean position.

A. Statement (I) is true, Statement (II) is true , statement (II) is the correct explanation for Statement (I).

B. Statement (I) is true, Statement (II) is true , statement (II) is not the correct

explanation for Statement (I).

C. Statement (I) is true, Statement (II) is false.

D. Statement (i) is false, Statement (II) is true.

Answer: B

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4. The phase difference between the instantaneous velocity and acceleration of a particle executing simple harmonic motion is:-

A. Statement (I) is true, Statement (II) is true , statement (II) is the correct explanation for Statement (I).

B. Statement (I) is true, Statement (II) is true , statement (II) is not the correct explanation for Statement (I).

C. Statement (I) is true, Statement (II) is false.

D. Statement (i) is false, Statement (II) is true.

Answer: B

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5. A body with constant acceleration always moves along a straight line.

A body with constant magnitude of acceleration may not speed up.

A. Statement (I) is true, Statement (II) is true , statement (II) is the correct explanation for Statement (I).

B. Statement (I) is true, Statement (II) is true , statement (II) is not the correct explanation for Statement (I).

C. Statement (I) is true, Statement (II) is false.

D. Statement (i) is false, Statement (II) is true.

Answer: D

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Exercise Comprehension

1. A car is moving towards south with a speed of $20ms^{-1}$. A motorcyclist is moving towards east with a speed of $15s^{-1}$. At a certain instant, the motorcyclist is due south of the car and is at a distance of $50m$from the car. The shortest distance between the motorcyclist and the car is.

A. 10 m

B. 20 m

C. 30 m

D. 40 m

Answer: C

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2. A car is moving towards south with a speed of $20ms^{-1}$. A motorcyclist is moving towards east with a speed of $15s^{-1}$. At a certain instant, the motorcyclist is due south of the car and is at a distance of $50m$from the car. The shortest distance between the motorcyclist and the car is.

A. $1/3s$

B. $8/3s$

C. $1/5s$

D. $8/5s$

Answer: D

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3. A man can swim at a speed of $3kmh^{-1}$ in still water. He wants to cross a $500-m$ wide river flowing at $2kmh^{-1}$. He keeps himself always at an angle to 120° with the river flow while swimming.

The time taken to cross the river is.

A. $\frac{3}{2}h$

B. $\frac{1}{6}h$

C. $\frac{1}{3\sqrt{3}}h$

D. none

Answer: C

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4. A man can swim at a speed of $3kmh^{-1}$ in still water. He wants to cross a $500-m$ wide river flowing at $2kmh^{-1}$. He keeps himself always at an angle to 120° with the river flow while swimming.

The drift of the man along the direction of flow, when he arrives at the opposite bank is.

A. $\frac{1}{6\sqrt{3}} km$

B. $6\sqrt{3} cm$

C. $3\sqrt{3} km$

D. $\frac{1}{3\sqrt{3}} km$

Answer: A

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5. To a stationary man, rain appears to be falling at his back at an angle 30° with the vertical. As he starts moving forward with a speed of $0.5 ms^{-1}$, he finds that the rain is falling vertically.

The speed of rain with respect to the moving man is.

A. 0.5

B. $1.0 ms^{-1}$

C. $0.5(\sqrt{3}) ms^{-1}$

D. $0.43ms^{-1}$

Answer: B

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6. To a stationary man, rain appears to be falling at his back at an angle 30° with the vertical. As he starts moving forward with a speed of $0.5ms^{-1}$, he finds that the rain is falling vertically.

The speed of rain with respect to the moving man is.

A. $0.5 ms^{-1}$

B. $1.0 ms^{-1}$

C. $0.5\sqrt{3} ms^{-1}$

D. $0.45 ms^{-1}$

Answer: C

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7. From a tower of height $40m$, two bodies are simultaneously projected horizontally in opposite direction, with velocities $2ms^{-1}$ and $8ms^{-1}$. respectively.

The time taken for the velocity vectors of two bodies to become perpendicular to each other is :

A. 0.1 s

B. 0.2 s

C. 0.4 s

D. 0.8 s

Answer: C

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8. From a tower of height $40m$, two bodies are simultaneously projected horizontally in opposite direction, with velocities $2ms^{-1}$ and $8ms^{-1}$. respectively.

The horizontal distance between two bodies, when their velocity are perpendicular to each other, is.

A. 1 m

B. 0.5 m

C. 2 m

D. 4 m

Answer: D

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9. From a tower of height $40m$, two bodies are simultaneously projected horizontally in opposite direction, with velocities $2ms^{-1}$ and $8ms^{-1}$. respectively.

The time taken for the displacement vectors of two bodies to be come perpendicular to each other is.

A. 0.1 s

B. 0.2 s

C. 0.8 s

D. 0.6 s

Answer: C

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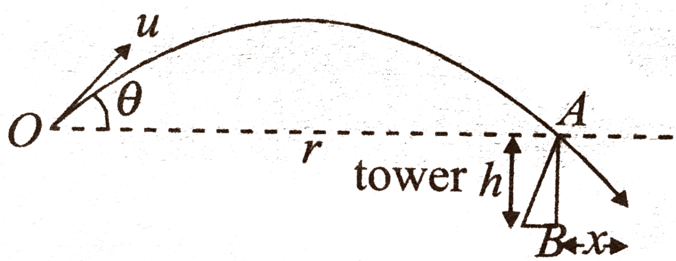
10. A ball is thrown from a point in level with velocity u and at a horizontal distance r from the top os a tower of height h.

How must the speed and angle of the projection of the ball be related to r in order that the ball may just go grazing the top edge of the tower ?



A. $gr = u^2 \sin 2\theta$

B. $gr = u^2 \sin \theta$

C. $gr = u^2 \cos 2\theta$

D. $gr = u^2 \cos \theta$

Answer: C

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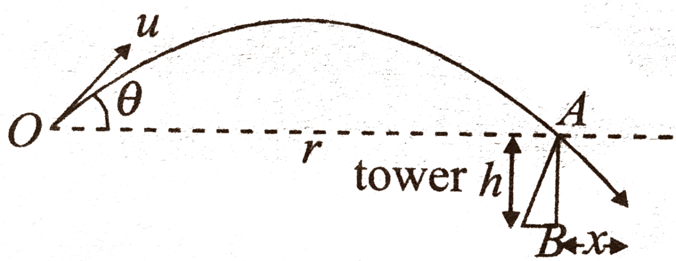
11. A ball is thrown from a point in level with velocity u and at a horizontal distance r from the top os a tower of height h.

At what horizontal distance x from the foot of the tower does the ball hit the ground ?



A. $\frac{u\cos\theta}{g}\left\{\left(u^2\sin^2\theta+gh\right)^{1/2}-u\sin\theta\right\}$

B.

$$\frac{u\cos\theta}{g}\left\{\left(u^2\cos^2\theta+2gh\right)^{1/2}-u\cos\theta\right\}$$

C. $\dfrac{u\cos\theta}{g}\left\{\left(u^2\cos^2\theta+gh\right)^{1/2}-u\cos\theta\right\}$

D. $\dfrac{u\cos\theta}{g}\left\{\left(u^2\cos^2\theta+gh\right)^{1/2}-u\cos\theta\right\}$

Answer: A

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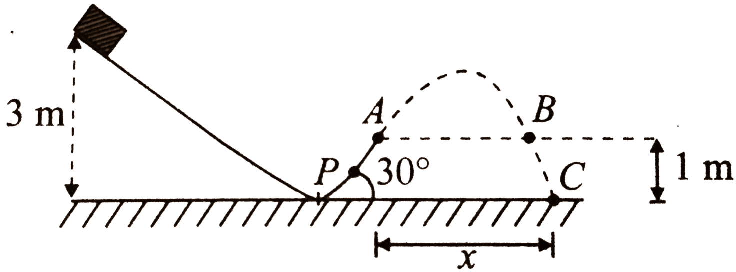
12. A $0.098kg$ block slides down a frictionless track as shown in (Fig. 5.208).



The time taken by the block to move from A to B is.

A. $\sqrt{g}$

B. $2\sqrt{g}$

C. $3\sqrt{g}$

D. $4\sqrt{g}$

Answer: A

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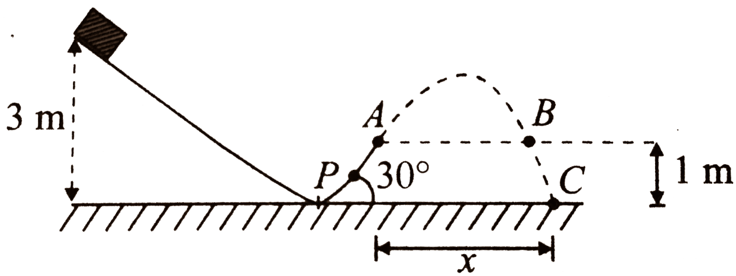
13. A $0.098 - kg$ block slides down a frictionless track as shown in (Fig. 5.208).



The time taken by the block to move from A to B is.

A. $\dfrac{1}{\sqrt{g}}$

B. $\dfrac{2}{\sqrt{g}}$

C. $\frac{3}{\sqrt{g}}$

D. $\frac{4}{\sqrt{g}}$

Answer: B

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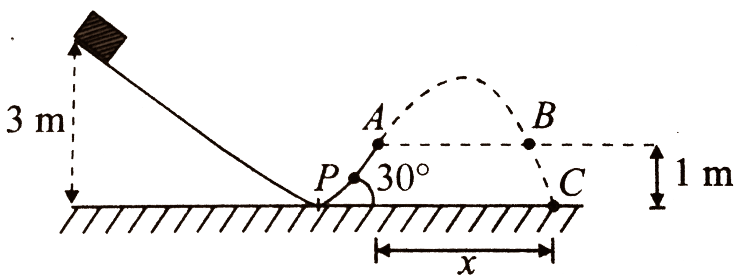
14. A $0.098 - kg$ block slides down a frictionless track as shown in (Fig. 5.208).



.

The time taken by the block to move from A to C is.

A. $\sqrt{\frac{3}{g}}$

B. $\sqrt{\frac{2}{g}}$

C. $\sqrt{\frac{1}{g}}$

D. $\frac{1+\sqrt{3}}{\sqrt{g}}$

Answer: D

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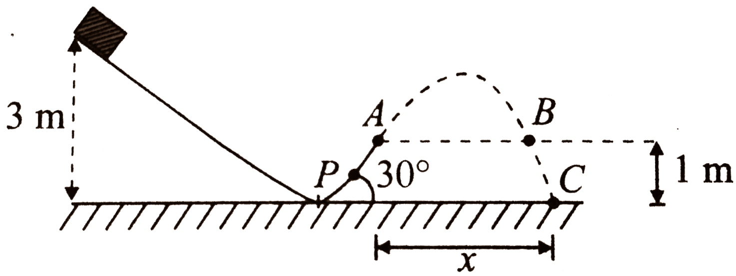
15. A $0.098 - kg$ block slides down a frictionless track as shown in (Fig. 5.208).



The horizontal distance x travelled by the block in moving from A to C is.

A. $(1 + \sqrt{3})m$

B. $(1 - \sqrt{3})m$

C. $(\sqrt{3} + 3))m$

D. g meter

Answer: C

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16. A projectile is thrown with velocity v at an angle θ with the horizontal. When the projectile is at a height equal to half of the maximum height,.

The vertical component of the velocity of projectile is.

A. $3v \sin \theta$

B. $v \sin \theta$

C. $\dfrac{v \sin \theta}{\sqrt{2}}$

D. $\dfrac{v \sin \theta}{\sqrt{3}}$

Answer: C

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17. A projectile is thrown with velocity v at an angle θ with the horizontal. When the projectile is at a height equal to half of the maximum height,.

The velocity of the projectile when it is at a height equal to half of the maximum height is.

A. $v\sqrt{\cos^2\theta + \frac{\sin^2\theta}{2}}$

B. $\sqrt{2}v\cos\theta$

C. $\sqrt{2}v\sin\theta$

D. $v\tan\theta\sec\theta$

Answer: A

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18. A body is thrown at an angle θ_0 with the horizontal such that it attains a speed equal to $\sqrt{\frac{2}{3}}$ times the speed of projection when the body is at half of its maximum height. Find the angle θ_0.

A. 15°

B. 30°

C. 45°

D. 60°

Answer: B

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19. A particle is projected with a speed u at angle θ with the horizontal. Consider a small part of its path near the highest position and take it approximately to be a circular arc. What is the radius of this circle? This radius is called the radius of curvature of the curve at the point.

A. $\dfrac{u^2 \cos^2 \theta}{2g}$

B. $\dfrac{\sqrt{3}u^2 \cos^2 \theta}{2g}$

C. $\frac{u^2 \cos^2 \theta}{g}$

D. $\frac{\left(\sqrt{3}u^2 \cos^2 \theta\right)}{g}$

Answer: C

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20. What is the radius of curvature of the parabola traced out by the projectile in the previous problem projected with speed v at an angle of theta with the horizontal at a point where the particle velocity makes an angle $\frac{\theta}{2}$ with the horizontal?

A. $\frac{u^2 \cos^2 \sec^3\left(\frac{\theta}{2}\right)}{g}$

B. $\frac{u^2 \cos^2 \sec^3\left(\frac{\theta}{2}\right)}{2g}$

C. $\frac{2u^2 \cos^2 \theta \sec^3\left(\frac{\theta}{2}\right)}{g}$

D. $\frac{u^2 \cos^2 \theta \sec^3\left(\frac{\theta}{2}\right)}{\sqrt{3g}}$

Answer: A

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21. A particle is projected with a speed u at an angle θ to the horizontal. Find the radius of curvature.

At the point where the particle is at a highest half of the maximum height H attained by it.

A. $\dfrac{2u^2\left(1+\cos^2\theta\right)^{3/2}}{g2\sqrt{2}\cos\theta}$

B. $\dfrac{u^2\left(1+\cos^2\theta\right)^{3/2}}{g2\sqrt{2}\cos\theta}$

C. $\dfrac{u^2\left(1-\sin^2\theta\right)^{3/2}}{g2\sqrt{2}\cos\theta}$

D. $\dfrac{u^2\left(1-\tan^2\theta\right)^{3/2}}{g2\sqrt{2}\cos\theta}$

Answer: B

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Exercise Integer

1. A particle is projected with velocity u at angle θ with horizontal. Find the time when velocity vector is perpendicular to initial velocity vector.

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2. From a tower of height $40m$, two bodies are simultaneously projected horizontally in opposite direction, with velocities $2ms^{-1}$ and $8ms^{-1}$. respectively.

The time taken for the displacement vectors of two bodies to be come perpendicular to each other is.

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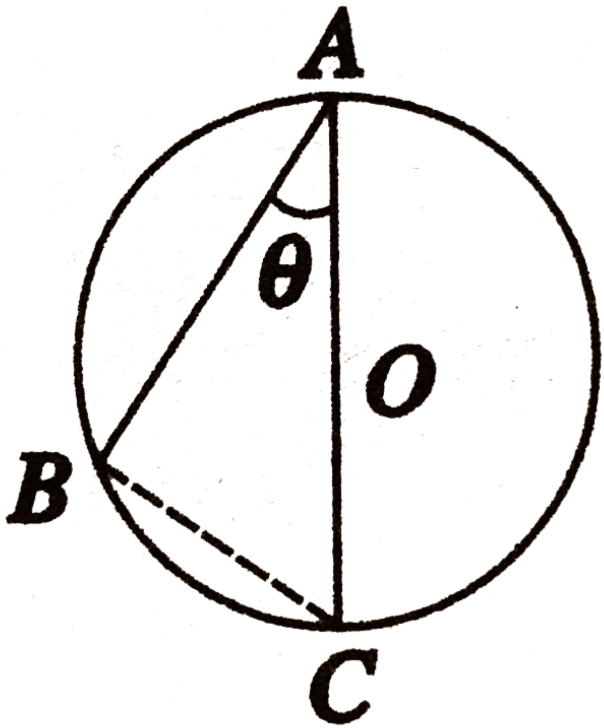
3. A bead is free to slide down on a smooth wire rightly stretched between points A and B on a vertical circle of radius $10m$. Find the time taken by the bead to reach point B, if the bead slides from rest from the highest point A on the circle.



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4. A golfer standing on the ground hits a ball with a velocity of $52m/s$ at an angle θ above the horizontal if $\tan\theta = \frac{5}{12}$ find the time for which the ball is at least $15m$ above the ground?

$(g = 10m/s^2)$

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5. A body is thrown with the velocity v_0 at an angle of θ to the horizon. Determine

$v_0 \text{in} ms^{-1}$ if the maximum height attained by the body is $5m$ and at the highest point of its trajectory the radius of curvature is $r = 3m$. Neglect air resistance. $\left[Use\sqrt{80}as9\right]$.

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6. A boy standing on a long railroad car throws a ball straight upwards. The car is moving on the horizontal road with an acceleration of $1\frac{m}{s^2}$ and the projectioon velocity into vertical direction is 9.8 m/s. How far behind the boy will the ball fall on the car?

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7. A staircase contains three steps each 10 cm high and 20 cm wide figure. What should be the minimum horizontal velocity of a bal rolling off the upper most plane so as to hit directly the lowest plane?

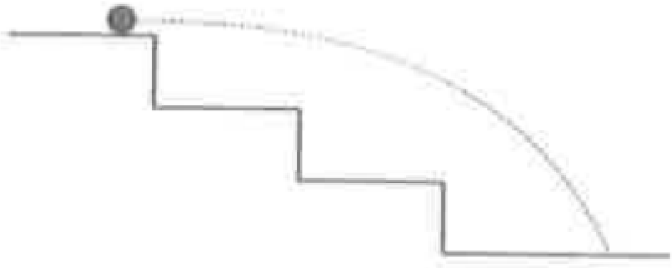

Figure 3-E9

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8. A particle is projected up an inclined plane of inclination β at an elevation $\propto$ to the horizontal. Find the ratio between

$\tan \propto$ and $\tan \beta$, if the particle strikes the plane horizontally.

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9. A particle is moving in a circle of radius R with constant speed. The time period of the particle is $t = 1$. In a time $t = T/6$, if the difference between average speed and average velocity of the particle is $2ms^{-1}$. Find the radius R of the circle (in meters).

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