



PHYSICS

BOOKS - DHANPAT RAI & CO PHYSICS (HINGLISH)

PROJECTILE MOTION

Example Solution

1. A passenger arriving in a new town wishes to go from the station to a hotel located

10km away on a straight road from the station. A dishonest cabman takes him along a circuitous path 23km long and reaches the hotel in 28 minutes . What is (a) the average speed of the taxi, (b) the magnitude of average velocity? Are the two equal ?

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2. A cyclist travels from centre O of a circular park of radius 1 km and reaches point P. After cycling along 1/4 th of the circumference

along PQ, he returns to the centre of the park along QO. If the total time taken is 10 minutes, calculate (i) net displacement (ii) average velocity and (ii) average speed of the cyclist.

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3. On an open ground , a motorist follows a track that turns to his left by an angle of 60° after every 500m. Starting from a given turn , specify the displacement of the motorist at the third, sixth and eighth turn. Compare the

magnitude of the displacement with total path length covered by the motorist in each case.

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4. An aircraft is flying at a height of 3400 m above the ground. If the angle subtended at a ground observation point by the aircraft positions 10 s apart is 30° , what is the speed of the aircraft ?

5. A projectile is fired horizontally with a velocity of $98ms^{-1}$ from the top of a hill 490 m high. Find (i) the time taken to reach the ground (ii) the distance of the target from the hill and (iii) the velocity with which the projectile hits the ground.

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6. A body is thrown horizontally from the top of a tower and strikes the ground after three

seconds at an angle of 45° with the horizontal. Find the height of the tower and the speed with which the body was projected. (Take $g=9.8m/s^2$)



7. A bomb is dropped from an aeroplane when it is directly above a target at a height of 1000m. The aeroplane is moving horizontally with a speed of $500kmh^{-1}$. By how much distance will the bomb miss the target ?



8. Two tall buildings face each other and are at a distance of 180 m from each other. With what velocity must a ball be thrown horizontally from a window 55 m above the ground in one building, so that it enters a window 10.9 m above the ground in the second building ?

9. A body is projected horizontally from the top of a cliff with a velocity of $9.8ms^{-1}$. What time elapes before horizontal and vertical velocities become equal ? Take $g = 9.8ms^{-2}$.

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10. Two paper screens A and B are separated by a distance of 100m. A bullet pierces A and B. The hole in B is 10cm below the hole in A. If the bullet is travelling horizontally at the time of hitting the screen A, calculate the velocity of the bullet when it hits the screen A. Neglect resistance of paper and air.

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11. A marksman wishes to hit a target just in the same level as the line of sight. How high from the target he should aim, if the distance of the target is 1600 m and the muzzle velocity of the gun is $800ms^{-1}$? Take $g = 9.8ms^{-2}$.



12. A body is projected with a velocity of $30ms^{-1}$ at an angle of 30° with the vertical. Find the maximum height, time of flight and the horizontal range.

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



14. The ceiling of a long hall is 25 m high. What is the maximum horizontal distance that a ball thrown with a speed of $40ms^{-1}$ can go without hitting the ceiling of the hall ?

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15. A bullet fired at an angle of 30° with the horizontal hits the ground 3 km away. By

adjusting the angle of projection, can one hope to hit a target 5 km away ? Assume the muzzle speed to be fixed and neglect air resistance.



16. A projectile has a range of 50 m and reaches a maximum height of 10 m. Calculate

the angle at which the projectile is fired.



17. Find the angle of projection for which the horizontal range and the maximum height are equal.



18. Prove that the maximum horizontal range is four times the maximum height attained by the projectile, when fired at an inclination so as to have maximum horizontal range.



19. Show that a given gun will shoot three times as high when elevated at an angle of 60° as when fired at angle of 30° but will carry the same distance on a horizontal plane.



20. A ball is thrown at angle θ and another ball is thrown at an angle $(90^{\circ} - \theta)$ with the horizontal direction from the same point with velocity $39.2ms^{-1}$. The second ball reaches 50



21. If R is the horizontal range for θ inclination and h is the maximum height reached by the projectile, Then maximum range is



22. For given value of u, there are two angles of projection for which the horizontal range is the same. Show that the sum of the maximum heights for these two angles is independent of the angle of projection.

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23. Show that there are two values of time for which is projectile is at the same height. Also

show that the sum of these two times is equal

to the time of flight.



24. A ball is kicked at an angle of 30° with the vertical. If the horizontal component of its velocity is $19.6ms^{-1}$, find the maximum height and horizontal range.

25. A fighter plane flying horizontally at an altitude of 1.5km with speed $720kmh^{-1}$ passes directly over head an anticraft gun. At what angle from the vertical should the gun be fired from the shell with muzzle speed $600ms^{-1}$ to hit plane.

At what minimum altitude should the pilot fly the plane to avoid being hit ? (Take g= 10 ms^{-2}).

26. At what angle should a body be projected with a velocity $24ms^{-1}$. Just to pass over the obstacle 16 m high at a horizontal distance of 32 m ? Take $g = 10ms^{-2}$.



27. A target is fixed on the top of a pole 13 metre high. A person standing at a distance of 50 metre form 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 ?



28. Two persons simultaneously aim and fire their guns at a bird sitting on a tree. The first person fires his shot with a speed of 100m/s at an angle of projection of 30° . The second person is ahead of the first by a distance of 50m and fire his shot with a speed of 80m/s. how must he aim his gun so that both the

shots hit the bird simultaneously. Calculate the distance of the foot of the tree from two persons and the height of the tree. With what velocities and when do the two shots hit the bird.

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29. What is the angular velocity of a second

hand and minute hand of a clock?

30. Calculate the angular speed of flywheel making 420 revolutions per minute.

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31. A circular wheel of 0.50 m radius is moving with a speed of $10ms^{-1}$. Find the angular speed.

32. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 seconds, what is the magnitude and direction of acceleration of the stone ?

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33. An aircraft executes a horizontal loop of radius 1 km with a steady speed of $900 kmh^{-1}$.

Compare its centripetal acceleration with the

acceleration due to gravity.



34. An insect trapped in a circular groove of radius 12 cm moves along the groove steadily and completes 7 revolutions in 100 s. (i) What is the angular speed and the linear speed of the motion ? (ii) Is the acceleration vector a constant vector ? What is its magnitude ?



35. The radius of the earth's orbit around the sun is $1.5 \times 10^{11}m$. Calculate the angular and linear velocity of the earth. Through how much angle does the earth revolve in 2 days?

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

is the magnitude and direction of the net acceleration of the cyclist on the circular turn ? Watch Video Solution

37. A particle moves in a circle of radius 4.0 cm clockwise at constant speed of $2ms^{-1}$. If \hat{x} and \hat{y} are unit acceleration vectors along X-axis and Y-axis respectively (in cms^{-2}), find the acceleration of the particle at the instant

half way between P and Q. Refer to Fig.5.14 (a).





Problen Solution

1. A particle of mass 100 g is fired with a velocity of $20ms^{-1}$ making an angle of 30° with horizontal. When it rises to the point of

its highest point, find the change in its

momentum.



2. A body of mass m is projected with velocity v at an angle of 45° with the horizontal. Find the change in its momentum at the end of flight.

3. The height y and the distance x along the horizontal plane of projectile on a certain planet (with no atmosphere on it) are given by $y = (8t - 5t^2)$ metre and x = 6t metre , where time t is in seconds. Find the initial velocity with which the projectile is projected.



4. Show that the motion of one projectile as seen from another projectile will always be a

straight line motion.

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5. A particle is projected horizontal with a speed u from the top of plane inclined at an angle θ with the horizontal. How far from the point of projection will the particle strike the plane?

6. A helicopter on a flood relief mission flying horizontally with a speed u at a altitude h, has to drop a food packet for a victim standing on the ground. At what distance from the victim should the food packet be dropped ?

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7. A ball is thrown from ground level so as to just clear a wall 4m high at a distance of 4 m and falls at a distance of 14 m from the wall.

Find the magnitude and direction of the initial

velocity.



8. 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:

9. A particle is projected over a traingle from one end of a horizontal base and 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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10. A particle is projected with velocity $2\sqrt{gh}$ so that it just clears two walls of equal height h which are at a distance 2h from each other.

Show that the time of passing between the walls is $2\sqrt{h/g}$.

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11. A shell is fired from a gun from the bottom of a hill along its slope. The slope of the hill is $\alpha = 30^{\circ}$, and the angle of the barrel to the horizontal $\beta = 60^{\circ}$. The initial velocity u of the shell is $21ms^{-1}$. Find the distance from the gun to the point at which the shell falls.



12. If the horizontal range of a projectile be a and the maximum height attained by it is b, then prove that the velocity of projection is

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13. The velocity of a projectile when it is at the greatest height is $(\sqrt{2/5})$ times its velocity when it is at half of its greatest height. Determine its angle of projection.

14. Particles P and Q of masses 20g and 40g, respectively, are projected from positions Aand B on the ground. The initial velocities of P and Q make angles of $45^{\,\circ}$ and $135^{\,\circ}$, respectively with the horizontal as shown in the fig. Each particle has an initial speed of 49m/s. The separation AB is 245m. Both particles travel in the same vertical plane and undergo a collision. After the collision Pretraces its path. The separation of Q from its
initial position when it hits the ground is



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15. Two towers AB and CD are situated a distance d apart as: shown in Fig. 1E.139 (a). AB is 20 m high and CD is 30 m high from the ground. An object of mass mis thrown from the top of AB horizontally with a velocity of 10 m/s towards CD.

Simultaneously another object of mass 2m is thrown from the ·top of CD at an angle of 60° to the horizontal towards AB with the same magnitude of initial velocity as that of the_ first' objects . The two objects move in the same vertical plane, collide in mid-air and stick to each other. Calculate the distance d between the towers.





on with a bob of mass 3M suspended by a massless string of length 10/3 metres and gets embeded in the bob. After the collision, the string moves through an angle of 120° . Find

(i) the angle θ ,

(ii) the vertical and horizontal coordinates of the initial position of the bob with respect to the point of firing of the bullet. Take $g = 10m/s^2$

17. Two guns situated at the top of a hill of height 10m fire one shot each with the same speed $5\sqrt{3}m/s$ at some interval of time. One gun fires horizontal and the other fores upwards at an angle of 60° with the horizontal. Two shots collide in air at a poit P. Find (i) time-interval between the firing and (ii) coordinates of the point P. Take the origin of coordinates system at the foot of the hill right below the muzzle and trajectorise in the x - yplane.



Problem For Self Practice

1. A cyclist moves along a circular path of radius 70 m. If he completes one round in 11 s, calculate (i) total length of path, (ii) magnitude of the displacement, (iii) average speed, and (iv) magnitude of average velocity.



2. A body is moving with a uniform velocity of $10ms^{-1}$ on a circular path of diameter 2.0 m. Calculate (i) the difference between the magnitude of the displacement of the body and the distance covered in half a round and (ii) the magnitude of the change in velocity of the body in half a round.

3. A plane is flying horizontal at a height of 1000m with a velocity of $100ms^{-1}$ when a bomb is released from it. Find (i) the time taken by it to reach the ground (ii) the velocity with which the bomb hits the target and (iii) the distance of the target.



4. From the top of a building 19.6 m high, a ball is projected horizontal. After how long

does it strike the ground ? If the line joining the point of projection to the point where it hits the ground makes an angle of 45° with the horizontal, what is the initial velocity of the ball ?

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5. A body is thrown horizontal from the top of a tower and strikes the ground after two seconds at angle of 45° with the horizontal. Find the height of the tower and the speed with which the body was thrown. Take $g=9.8ms^{-2}.$

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6. Two tall buildings are situated 200 m apart. With what speed must a ball be thrown horizontally from the window 540 m above the ground in one building, so that it will enter a window 50 m above the ground in the other ?



7. A stone is dropped from the window of a bus moving at $60kmh^{-1}$. If the window is 1.96 m high, find the distance along the track, which the stone moves before striking the ground.

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8. An aeroplane is flying in a horizontal direction with a velocity 600km/h at a height of 1960 m. When it is vertically above the point A on the ground, a body is dropped from it.

The body strikes the ground at point B.

Calculate the distance AB.



9. A mailbag is to be dropped into a post office from an aeroplane flying horizontally with a velocity of $270kmh^{-1}$ at a height of 176.4 m above the ground. How far must the aeroplane be from the post office at the time of dropping the bag so that it directly falls into the post office ?





10. In between two hills of heights 100 m and 92 m respectively. There is a valley of breadth 16 m. If a vehicle jumps from the first hill to the second, what must be its minimum horizontal velocity so that it may not fall into the valley ? Take $g = 9ms^{-2}$



11. A ball is projected horizontally from a tower

with a velocity of $4ms^{-1}$. Find the velocity of

the ball after 0.7 s. Take $g=10ms^{-2}$.



12. A shell is fired at an angle of 30° to the horizontal with a velocity of $392ms^{-1}$. Find the time of flight, horizontal range and maximum height attained.



13. A football player kicks a ball at an angle of 37° to the horizontal with an initial speed of $15ms^{-1}$. Assuming that the ball travels in a vertical plane, calculate (i) the time at which the ball reaches the highest point (ii) the maximum height reached (iii) the horizontal range of the projectile and (iv) the time for which the ball is in air.

14. A body is projected with a velocity of $20ms^{-1}$ in a direction making an angle of 60° with the horizontal. Determine its (i) position after 0.5 s and (ii) the velocity after 0.5s.



15. The maximum vertical height of a projectile is 10 m. If the magnitude of the initial velocity is $28ms^{-1}$, what is the direction of the initial velocity. ? Take $g = 9.8ms^{-2}$.



16. A bullet fired from a gun with a velocity of $140ms^{-1}$ strikes the ground at the same level as the gun at a distance of 1 km. Find the angle of inclination with the horizontal at which the bullet is fixed. Take $g = 9.8ms^{-2}$.

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17. A bullet is fired at an angle of 15° with the horizontal and hits the ground 6 km away. Is it

possible to hit a target 10 km away by adjusting the angle of projection assuming the initial speed to be the same ?

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18. A cricketer can throw a ball to maximum horizontal distance of 160 m. Calculate the maximum vertical height to which he can throw the ball. Given $g = 10ms^{-2}$.

19. Find the minimum velocity for which the

horizontal range of a projectile is 39.2 m.



20. A bullet fired from a rifle attains a maximum height of 5 m and crosses a range of 200 m. Find the angle of projection.



21. A shot is fired at a distance of 78.4 m from the foot of a pole 39.2 m high so that it just passes over it. Find the magnitude and the direction of the velocity of the shot.



22. A ball is thrown upwards with a velcoity of 80m/s at an angle of 30° to the horizontal .

Find its velcituy after one second.

23. A football is kicked with speed $20ms^{-1}$ at a projection angle of 45° from the ground. A receiver on the goal line 20m away in the direction of the kick runs the same instant to meet the ball. What must be his speed, if he has to catch the ball before it hits the ground ? Take $g = 10ms^{-2}$.

24. A bullet fired at an angle of 60° with the vertical hits the ground at a distance of 2 km. Calculate the distance at which the bullet will hit the ground when fired at an angle of 45° , assuming the speed to be the same.

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25. A person observes a bird on a tree 39.6 m high and at a distance of 59.2 m. With what

velocity the person should throw an arrow at

an angle of 45° so that it may hit the bird ?



26. A bomb is fired from a cannon with a velocity of $1000ms^{-1}$ making an angle of 30° with the horizontal $(g = 9.8ms^{-2})$, (i) What is the time taken by the bomb to reach the highest point? (ii) What is the total time of its motion? (iii) With what speed the bomb will hit the ground and what will be its direction of

motion while hitting ? (iv) What is the maximum height attained by the bomb ? (v) At what distance from the cannon the bomb will hit the ground ?



27. A ball is thrown from the top of a tower with an initial velocity of 10 m//s at an angle of 30° above the horizontal. It hits the ground at a distance of 17.3 m from the base of the

tower. The height of the tower $\left(g=10m\,/\,s^2
ight)$

will be



29. A body is projected with a veocity of $40ms^{-1}$. After 2s it fcrosses a vertical pole of height 20.4m Find the angle of projection and horizontal range of projectile. (g = 9.8 ms^(-2)).



30. For the top of a tower 156.8m high, a projectile is thrown up with a velcity of $39.2ms^{-1}$, makingan angle $30\%(\circ)$ with borizontal direction. Find the distance from

the foot of tower wher it strikes the ground

and the time taken byit do so.



31. Two particles are thrown from the same point with the same velocity of $49ms^{-1}$. First is projected making angle θ with the horizontal and second at an angle $(90^{\circ} - \theta)$. The second particle is found to rise 22.5 m higher than the first. Find the height to which each particle will rise.



32. A boy wants to throw a letter wrapped over a stone to his friend across the street 40 m wide. The boy's window is 10 m below the friend's window. How should he throw the ball ?

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33. Find the angle of projection for a projectile

motion whose rang R is (n) times the

maximum height H.

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34. A body A of mass m is thrown with velocity v at an angle of 30° to the horizontal and another body B of the same mass is thrown with velocity v at an angle of 60° to the horizontal, find the ratio of the horizontal range and maximum height of A and B.



35. The greatest height to which a boy can throw a stone is (h). What will be the greatest distance on horizontal surface upto which the boy can throw the stone with the same speed ? Neglect the air friction.

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36. A ball of mass (m) is thrown vertically up. 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. What is the ratio of

the height attained by two balls.



37. As shown in Fig. 5.29, a body is projected with velocity u_1 from the point A. At the same time another body is projected vertically upwards with velocity u_2 from the point B. What should be the value of u_1/u_2 for both





38. The kinetic energy of a projectile at the highest point of its path is found to be $3/4^{th}$ of its initial kinetic energy. If the body is

projected from the ground, the angle of

projection is

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39. A projectile is projected in the upward direction making an angle of 60° with the horizontal direction with a velocity of $147ms^{-1}$. After what time will its inclination with the horizontal be 45° ?

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40. Which is greater , the angular velocity of the hour hand of a watch or angular velocity of earth around its own axis ?

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41. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/hr . The centripetal force is

42. A body of mass 10 kg revolves in a circle of diameter 0.40 m, making 1000 revolutions per minute. Calculate its linear velocity and centripetal acceleration.

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43. The seocnd-hand of a watch is 3.0 cm long.

Calculate the linear speed of its top.



44. Calculate the centripetal acceleation of a point on the equator of earth due to the rotatin of earth about its wn axis . Radius of earth = 6400 km.

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45. Assuming that the moon completes one revolution in a circular orbit around the earth in 27.3 days, calculate the acceleration of the
moon towards the earth. The radius of the circular orbit can be taken as $3.85 imes 10^5 km$.



46. What is the angular velocity of a geostationary satellite if unit of time is an hour and that of angle is a degree ?

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47. The wheel of an automobile is rotating with 4 rotations per second. Find its angular velcoity. If the radius of the fly wheel, is 50*cm*, find the linear velcotiy of a point on its cicrumfernce.

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48. 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.



49. Calculate the linear acceleration of a particle of a particle moving in a circle of radius 0.4 m at the instant when its angular velocity is 2 rad s^{-1} and its angular acceleration is 5 rad s^{-2} .

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50. A threaded rod with 12turns/cm and diameter 1.18cm is mounted horizontally. A bar with a threaded hole to match the rod is screwed onto the rod. The bar spins at 216rev/ min . How long will it take for the bar to move 1.50cm along the rod ?

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