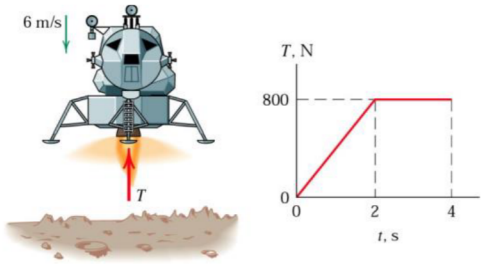
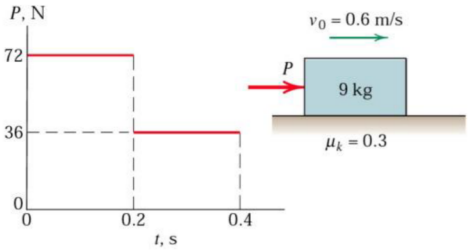
Module 5 Part 3 Kinetics 3 (Impulse –Momentum-Collision)

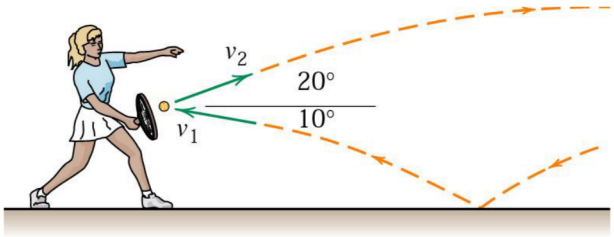
1. The 200-kg lunar lander is descending onto the moon's surface with a velocity of 6 m/s when its retro-engine is fired. If the engine produces a thrust T for 4 s which varies with the time as shown and then cuts off, calculate the velocity of the lander when t=5 s, assuming that it has not yet landed. Gravitational acceleration at the moon's surface is 1.62 m/s^2.



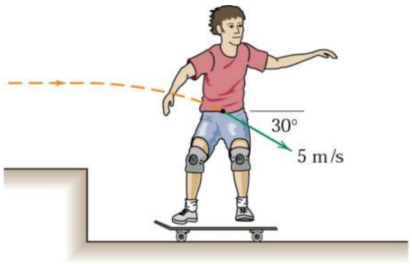
2. The 9-kg block is moving to the right with a velocity of 0.6 m/s on a horizontal surface when a force P is applied to it at time t=0. Calculate the velocity *v* of the block when t=0.4 s. The kinetic coefficient of friction is m_k=0.3.



3. A tennis player strikes the tennis ball with her racket while the ball is still rising. The ball speed before impact with the racket is v_1=15 m/s and after impact its speed is v_2=22 m/s, with directions as shown in the figure. If the 60-g ball is in contact with the racket for 0.05 s, determine the magnitude of the average force R exerted by the racket on the ball. Find the angle b made by R with the horizontal.

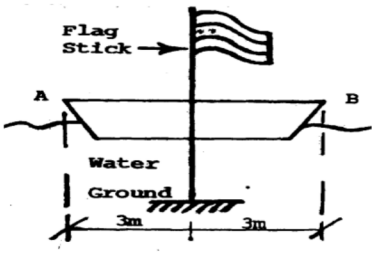


4. The 40-kg boy has taken a running jump from the upper surface and lands on his 5-kg skateboard with a velocity of 5 m/s in the plane of the figure as shown. If his impact with the skateboard has a time duration of 0.05 s, determine the final speed v along the horizontal surface and the total normal force N exerted by the surface on the skateboard wheels during the impact.



5. A boat 6m long & having a mass of 150 Kg is stationary on still lake water. A flag stick is anchored vertically in the ground below & its distance from end A of the boat is 3m. A man of 50 Kg standing at end A starts walking along the boat in direction AB at 2 m/s w.r.t. boat. Find the time required by the man to pass the flag stick.

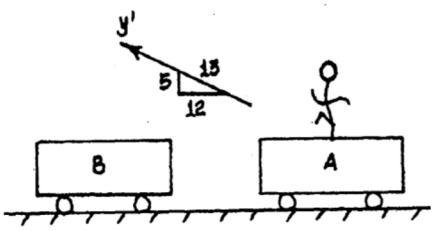
(Ans : 2 sec, S_B = -1 m)



6. Two men lined up at one end of a boat, initially at rest, and run in succession with velocity u= 3 m/s relative to boat and dive off at the far end. Neglecting resistance of water to horizontal motion of the boat, find its velocity after the second man dives. Each man weighs 750 N and the boat weighs 4500 N. (Ans : - 0.8036 m/s)

7. The boy jumps off the flat car at A with a velocity v'= 4 m/s relative to he car as shown. If he lands on the second flat car at B, determine the final speeds of both cars after the motion. Each car has a mass of 80 kg. The boy mass is 60 kg. Both cars are originally at rest. Neglect the weight of the car's wheel.

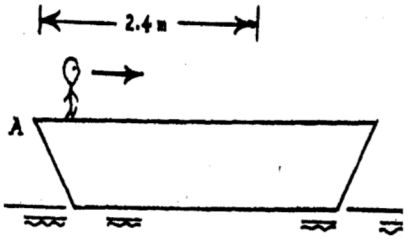
(Ans : VA/s, $V_{(BOY \& Car B)}$ = 0.904 m/s)



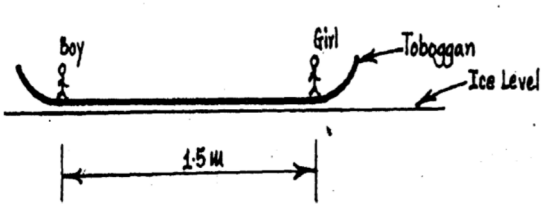
8. A man of mass 75 Kg & boy of mass 25 Kg dive off the end of a boat of mass 200 Kg so that their relative horizontal velocity w.r.t. boat is 3 m/s. If initially the boat is at rest find its final velocity (i)The two dive off simultaneously. (ii)The man dives first followed by boy. (iii) The boy dives first followed by man.

(Ans : (i) -1 m/s (ii) -1.083 m/s (iii) -1.068 m/s)

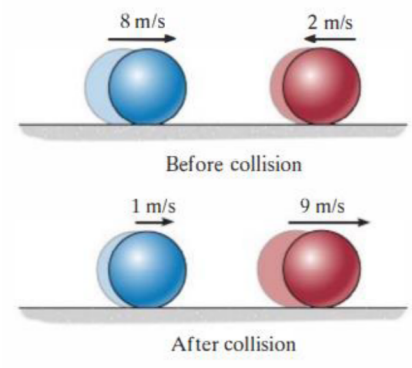
9. A man of weight 500 N is standing in a boat of weight 2000 N. The boat is initially at rest. The man moves from end A to the right a distance equal to 2.4m & stops. Find the corresponding displacement of boat.



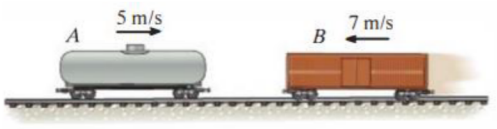
10. A boy having a mass of 60 Kg & a girl having a mass of 50 Kg stand motionless at the end of boat which has a mass of 30 Kg. If they exchange position, find the corresponding displacement of boat.



11.Determine the coefficient of restitution e between ball A and ball B. The velocities of A and B before and after the collision are shown



12. The 15-Mg tank car A and 25-Mg freight car B travel towards each other with the velocities shown. If the coefficient of restitution between the bumpers is e = 0.6, determine the velocity of each car just after the collision.



13. Two particles of masses 10 Kg & 20 Kg are moving along a straight line towards each other at velocities 4 m/s & 1 m/s respectively. If e = 0.6, find the velocities of the particles immediately after their collision and loss of K.E.

(Ans : -1.33m/s, 1.67m/s, 53.27J)

14. Two particles of masses 8 kg and 1 kg are moving towards each other at velocities of 3 m/s rightwards and 10 m/s leftwards along a straight line. If the velocity of 1 kg particle is 4 mIs rightwards after collision, determine the final velocity of 8 kg particle and coefficient of restitution.

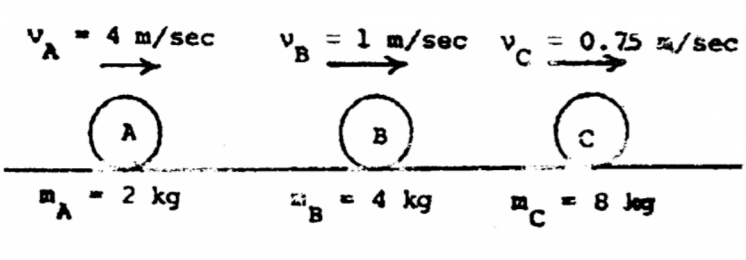
(Ans : 1.25m/s, e = 0.211)

15. Two masses A (8 kg), B (2 kg) moving in the same straight line collide with each other. Before collision and after collision both of them are moving in the same direction. If initial velocities of A and B are U_A = 2 m/s U_B = I m/s respectively and if the final velocity of B is V_B = 2 m/s find (i) Velocity of A after collision = V_A and (ii) Coefficient of restitution = e for the two masses

(Ans : 1.75m/s, e = 0.25)

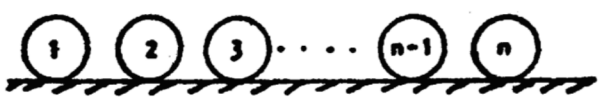
16. Three perfectly elastic balls A, B, C of masses 2 Kg, 4 Kg and 8Kg move along a line, with velocities 4 m/s, 1 m/s, and 0.75 m/s respectively. If the ball A strikes ball B which in turn strikes ball C, determine the velocities of the three balls after impact.

(Ans : 0, 3m/s, 2.25m/s)



17. A series of' n' identical balls is shown on a smooth horizontal surface. If number "1" ball moves horizontally with a velocity 'u' and collides with number '2' which in turn collides with 3' and so on, and if the coefficient of restitution for each impact is 'e' show that the velocity of the n^{th} ball is given by

$$V_n = \frac{(1+e)^{n-1}.u}{2^{(n-1)}}$$



18. A body of mass M moves in outer space with velocity V. it is desired to break the body into two parts so that the mass of one part is 1/10 of the total mass. After explosion the heavier part comes to rest while lighter part continues to move in the original direction of motion. Find the velocity of smaller part.

(Ans : 10V)

19. A 50 gm ball is dropped from a height of 600 mm on a small plate. It re-bounds to a height of 400 mm when the plate directly rests on the ground and to a height of 250 mm when a foam rubber mat is placed between the plate and the ground. Determine

(i) Coefficient of restitution between ball and plate (ii) Mass of plate.

(Ans : e = 0.82, 470gm)

20. A billiard ball moving with a velocity of 5 m/sec strikes a smooth horizontal floor at an angle of 45° with horizontal. If the coefficient of restitution is 0.6, what is the velocity with which the ball rebounds?

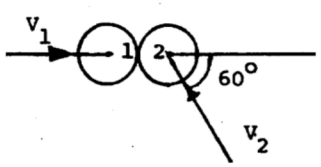
(Ans : 4.13m/s, θ = 30.92°)

21. A body of mass 1000 kg moving at 30 km/hr towards North collides with another body of mass 2000 kg moving at 20 km/hr towards East. If the two bodies, on collision, coalesce, determine the final velocity of the combined body.

(Ans : 16.67 KPH, θ = 36.87°)

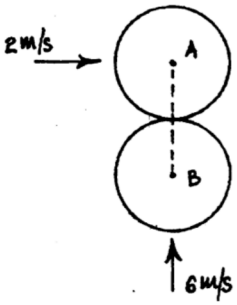
22. Two billiard balls of equal masses collide with velocities V_1 = 1.5 m/s and V_2 = 2 mIs. Find velocities of balls after impact and percentage loss in kinetic energy. Coefficient of restitution is 0.9.

(Ans : 0.875m/s, 2.21m/s at θ = 51.55° , 9.6%)



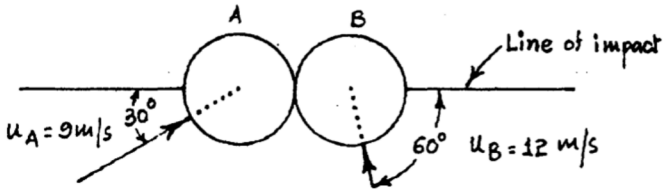
23. Two identical balls of 120 grams collide when they are moving with velocity perpendicular to each other as shown in the figure. Assuming that the line of impact is in the direction of motion of ball B determine the velocity of ball A and B completely after the impact. Take e = 0.8.

(Ans : V_A = 5.76m/s , V_B = 0.6 m/s↑)



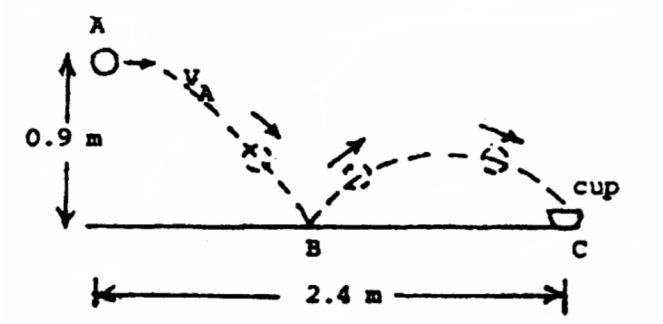
24. The magnitude and direction, of two identical smooth balls before central oblique impact are as shown in the figure. Assuming e = 0.90 determine the magnitude and direction of the velocity of each ball after impact.

(Ans : V_A = 6.96m/s , V_B = 12.58m/s)



25. Determine the horizontal velocity V_A at which we must throw the ball so that it bounces once on the surface and then lands into the cup at C. Take coefficient of restitution between ball and surface as e=0.6 and neglect the size of the cup.

(Ans : 2.55m/s)

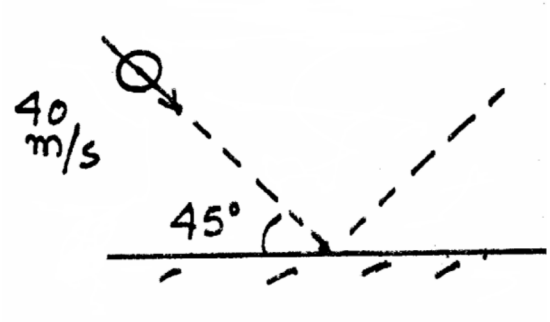


26. A heavy elastic ball drops from the ceiling of a room and after rebounding twice from the floor reaches a height equal to one half of the height of ceiling. Find the coefficient of restitution.

(Ans : e = 0.84)

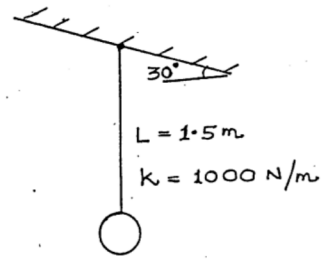
27. If the co-efficient of restitution is 0.7. Determine magnitude and direction ol velocity of bail after impact.

(Ans :

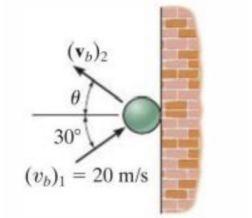


28. A ball of weight 20 N is suspended from an elastic cord tied to an inclined ceiling. It is stretched vertically down by 0.3m and then released. The ball travels vertically up and strikes the ceiling. Find the speed of the ball— (I) Just before impact. (ii) Just after impact Take e = 0.7.

(Ans : (i) 3 m/s (ii) 2.35m/s at 50.5° Ist quadrant)



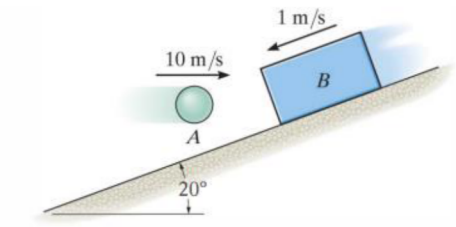
29. The ball strikes the smooth wall with a velocity of V_{b1}= 20 m/s. If the coefficient of restitution between the ball and the wall is e = 0.75, determine the velocity of the ball just after the impact.



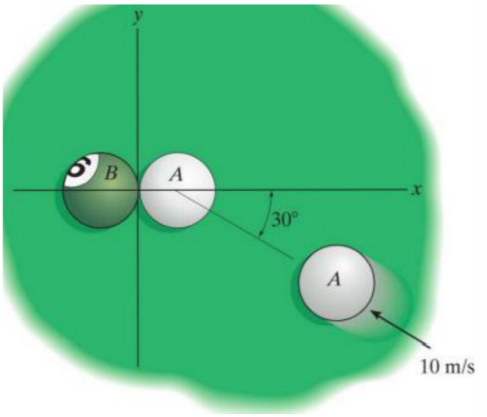
30. The 5-Mg truck and 2-Mg car are traveling with the free-rolling velocities shown just before they collide. After the collision, the car moves with a velocity of 15 kmjh to the right relative to the truck. Determine the coefficient of restitution between the truck and car and the loss of energy due to the collision.

31. The 2-kg ball is thrown so that it travels horizontally at 10 m/s when it strikes the 6-kg block as it is traveling down the inclined plane at 1 m/s. If the coefficient of

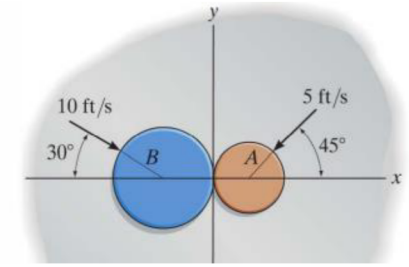
restitution between the ball and the block is e = 0.6, determine the speeds of the ball and the block just after the impact.



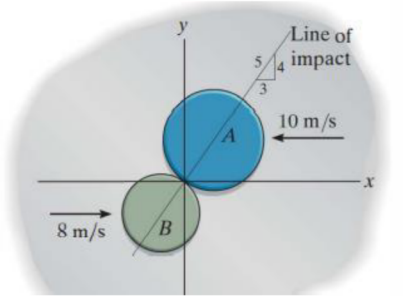
32. The pool ball A travels with a velocity of 10 mls just before it strikes ball B, which is at rest. If the masses of A and B are each 200 g, and the coefficient of restitution between them is e = 0.8, determine the velocity of both balls just after impact.



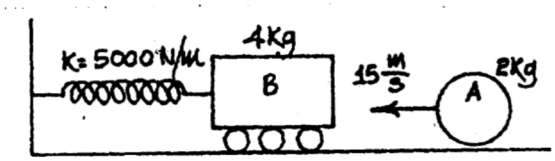
33. Two disks A and B weigh 2 kg and 5 kg, respectively. If they are sliding on the smooth horizontal plane with the velocities shown, determine their velocities just after impact. The coefficient of restitution between the disks is e = 0.6.



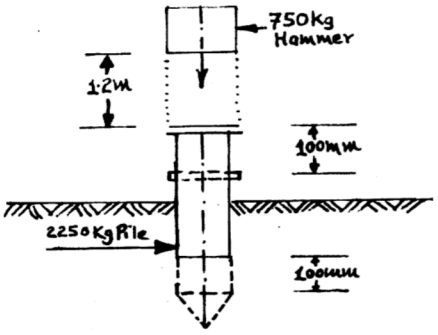
34. Disks A and B have a mass of 15 kg and 10 kg, respectively. If they are sliding on a smooth horizontal plane with the velocities shown, determine their speeds just after impact. The coefficient of restitution between them is e = 0.8.



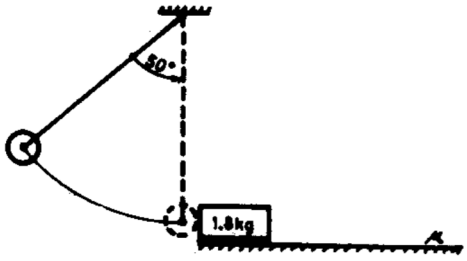
35. A 2 kg sphere A is moving to the left with a velocity of 15 m/s when it strikes the vertical face of 4 kg block B which is at rest. The block B is supported on rollers and is attached to a spring of constant k= 5000 N/m as shown in the figure. If e = coefficient of restitution for the block and sphere 0.75, determine the maximum compression - shortening of the spring due to the impact. Neglect friction.



36. A 750 kg hammer of a drop hammer pile - driver falls from a height of 1.2 m on to the top of a pile of mass 2250 kg. The pile is driven 100 mm into the ground because of the impact. What is the average resistance to penetration offered by the ground after the impact? Assume perfectly plastic impact.



37. A pendulum, length of spring 0.9 m, having mass of the bob 1.6 kg is released from rest as shown in the Fig. It strikes a block of mass 1.8 kg at rest on a rough horizontal floor. After impact the pendulum comes to rest and the block moves through a distance of 1.3 m and ultimately comes to rest. Find (1) The coefficient of restitution, (2) The coefficient of friction.



[Ans. (1) e = 0.889, (2) μ= 0.1953]

38. The pile driver weighing 2500 N drops freely through a height of 3m on the top of a pile which weigh 500 N. If the pile is driven in the ground by 75 mm, determine the average resistance of the ground to pile-driving and the amount of energy lost in impact.

(Ans : 86.2 KN)

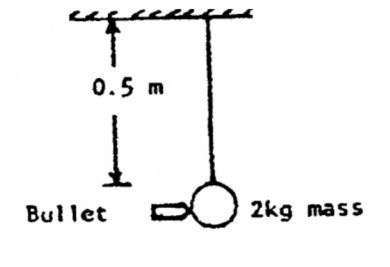
39. A ballistic pendulum consists of a sand box weighing 25 kg which is suspended from a cord 3 m long. A shell weighing 500 gm is fired horizontally into the box and remains embedded in it. Because of impact, the sand box swings through an angle of 30°. Find the velocity with which the shell strikes the box and the loss in energy of the system.

(Ans : 144.61 m/s, 5125.18 J)

40. A bullet of mass 10 gm is moving with a velocity of 100 m/s arid hits a 2 kg bob of a simple pendulum, horizontally, as shown in the fig. Determine the maximum angle through which the pendulum string 0.5 in long may swing, if

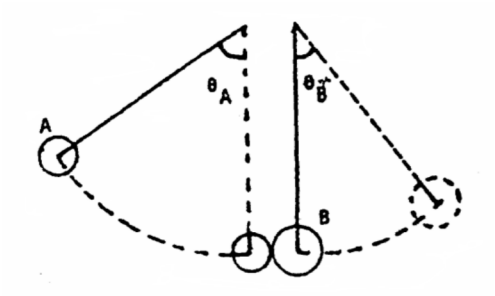
i) the bullet gets embedded in the bob. ii) the bullet escapes from the other end of the bob with a velocity 10 m/s.

(Ans : (i) 12.94° (ii) 11.65°)



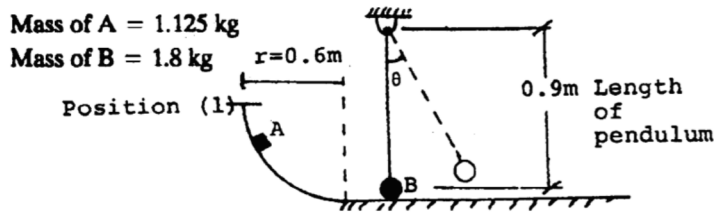
41. A 2 kg sphere A is released from rest when θ_A= 60º as shown in the sketch, and strikes a sphere B of mass 4 kg which is at rest. If the impact is assumed to be perfectly elastic, determine the value of θ_B corresponding to the highest position to which the sphere B will rise.

(Ans : 38.94°)



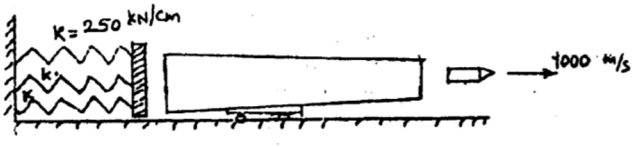
42. Block A is released from rest in position land slides without friction until it strikes the ball B of a simple pendulum. Knowing that coefficient of restitution between A and B as 0.90, determine (I) the velocity of B immediately after impact; (ii) the maximum angular displacement of the pendulum.

(Ans : (i) 2.53m/s (ii) 49.875°)



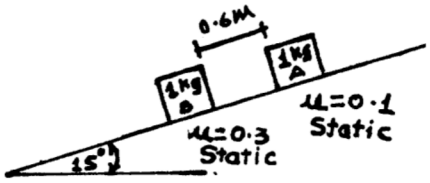
43. A gun of a shore battery is nested by three springs each of stiffness = 250 KNIcm as shown in the figure. The gun fires a 500 kg shell with a muzzle velocity of 1000 m/s. Calculate the total recoil and the maximum force developed in each spring if the gun has a mass of 80,000 kg.

(Ans : V_{Gun} = 6.25m/s , 0.204m, 5100 KN)



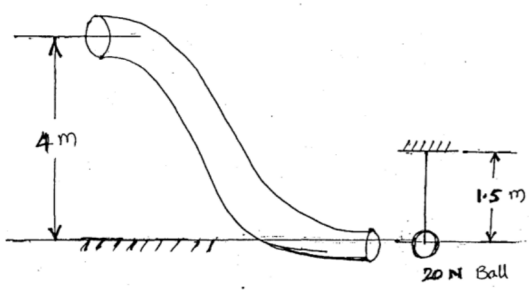
44. At t = 0, both blocks are released from the position shown. Find (I) the time at which impact occurs (ii) if e = 0.8, what are the velocities of blocks immediately after impact. Take static friction between block A and surface in incline a 0.1 and surface of incline as 0.3.

(Ans : t = 0.868 sec, V_A = 0.137m/s, V_B = 1.243 m/s)



45. A 40 N ball traverse a frictionless tube as shown in figure, and falls through a height of 4 m. It then strikes a 20 N ball hung from a rope, 1.5 m long. Determine the height to which the hanging ball will rise (i) If the collision is perfectly elastic and (ii) If the co-efficient of restitution is e = 0.7.

(Ans :



46. A bullet, weighing 0.25 N, strikes and enters a wooden block, of weight 50 N, with a horizontal velocity of 600 mIs. Wooden block is displaced through a distance of 90 cm, due to this impact, on the horizontal rough floor. Find the coefficient of friction between the block and the rough floor.

[Ans $\mu = 0.5$]