PHYSICS

BOOKS - DC PANDEY PHYSICS (HINGLISH)

CENTRE OF MASS, LINEAR MOMENTUM AND COLLISION

Example

1. Two particles of masses 1kg and 2kg are located at $x = 0$ and $x = 3m$. Find the position of their centre of mass.

A. 2m from 1 kg

B. 2m from 2 kg

C. 1m from 1 kg

D. none of these

Answer: A

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2. The position vector of three particles of masses $m_1 = 1kg.$

$m_2 = 2kg$ and $m_3 = 3kg$ are $r_1 = \left(\hat{i} + 4\hat{j} + \hat{k}\right)m$, $r_2 = \left(\hat{i} + \hat{j} + \hat{k}\right)m$ and $r_3 = \left(2\hat{j} - \hat{j} - 2\hat{k}\right)m$ respectivley. Find the position vector of their centre of mass.

A. $\left(1.5\hat{i} + 0.5\hat{j} - 0.5\hat{k}\right)m$

B. $\left(0.5\hat{i} + 1.5\hat{j} - 0.5\hat{k}\right)m$

C. $\left(1.5\hat{i} + 0.5\hat{j} + 0.5\hat{k}\right)m$

D. $\left(\hat{i} + 0.5\hat{j} - 0.5\hat{k}\right)m$

Answer: A

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3. Four particles of masses 1kg, 2kg, 3kg and 4kg are placed at the four vertices A, B, C and D of a square of side 1m. Find the position of centre of mass of the particles.

A. $(0.5, 0.3)$

B. $(0.4, 0.3)$

C. $(0.5, 0.8)$

D. $(0.7, 0.3)$

Answer: A

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4. A rod of length L is placed along the x-axis between $x = 0$ and $x = L$. The linear mass density (mass/length) ρ of the rod varies with the distance x from the origin as $\rho = a + bx$. Here, a and b are constants. Find the position of centre of mass of this rod.

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5. Find the position of centre of mass of the uniform lamina shown in figure.

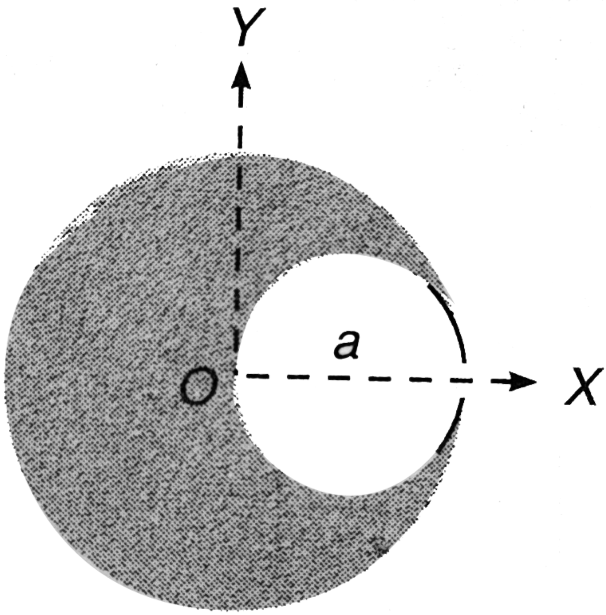

Fig. 11.12

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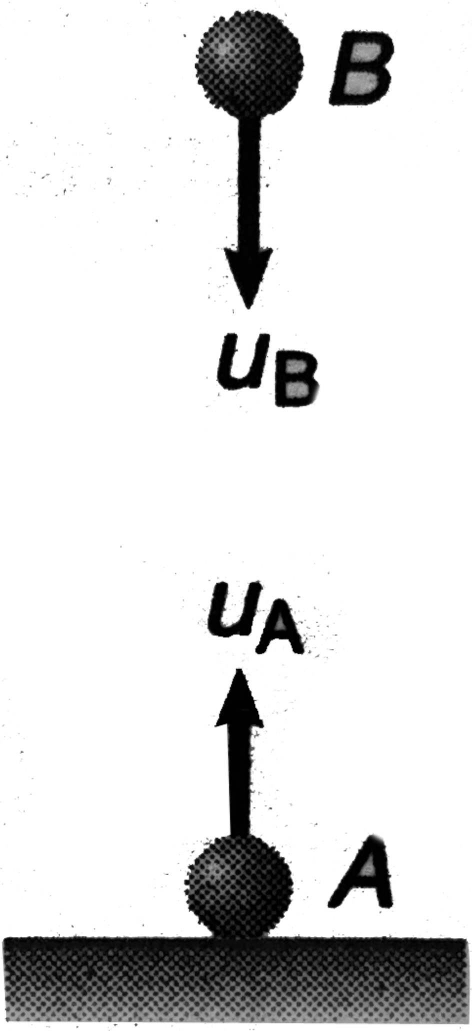
6. Two particles A and B of masses 1kg and 2kg respectively are projected in the directions shown in figure with speeds $u_A = 200 m / s$ and $u_B = 50 m / s$. Initially they were $90 m$ apart. They collide in mid air and stick with each other. Find the maximum height attained by the centre of mass of the particles. Assume acceleration due to gravity to be constant.

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



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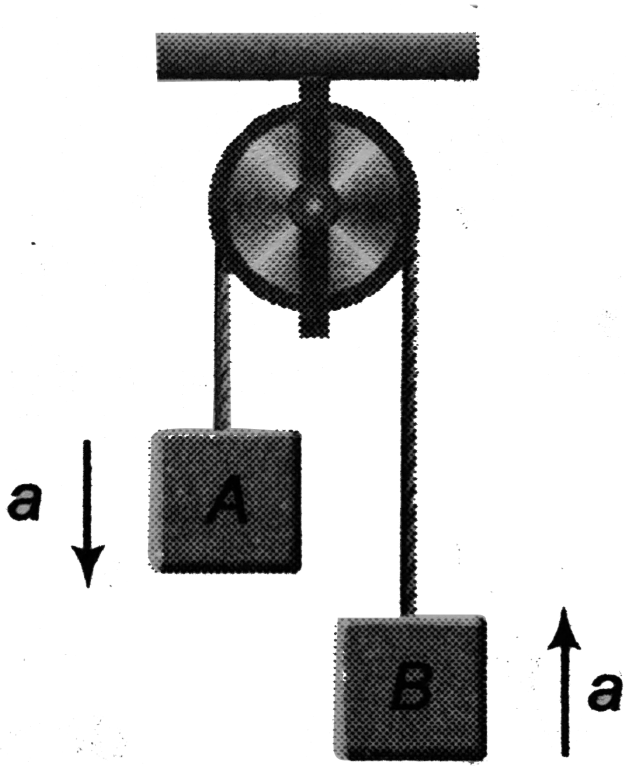
7. In the arrangement shown in Figure, $m_A = 2kg$ and $m_B = 1kg$. String is light and inextensible. Find the acceleration of centre of mass of both the blocks. Neglect friction everywhere.



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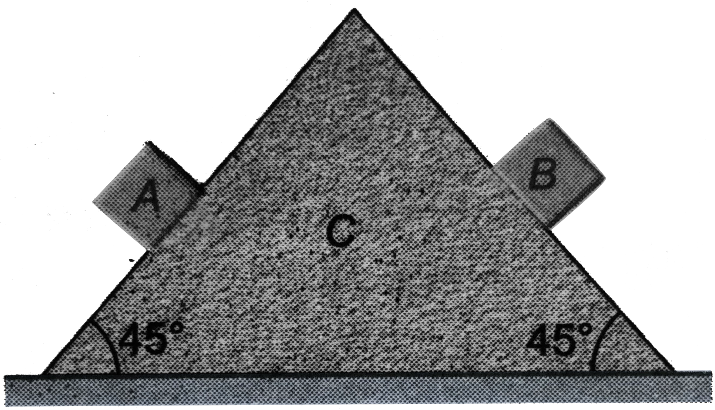
8. Two blocks A and B of equal masses are released on two sides of a fixed wedge C as shown in figure. Find the acceleration of centre of mass of blocks A and B. Neglect friction.



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9. Linear momentum of particle is increased by

(a) 100% (b) 1%

without changing its mass. Find percentage increase in its kinetic energy in both cases.

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10. Kinetic energy of a particle is increased by

(a) 50% (b) 1%

Find percentage change in linear momentum.

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11. Two blocks A and B of masses 1kg and 2kg are connected together by means of a spring and are resting on a horizontal frictionless table. The blocks are then pulled apart so as to stretch the spring and then released. Find the ratio of their,

(a) speed

(b) magnitude of momentum and

(c) kinetic energy at any instant.

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12. A gum (mass=M) fires a bullet (mass=m) with speed v_r relative to barrel of the gum which is inclined at an anlge of 60° with horizontal. The gun is placed over a smooth horizontal surface. Find the recoil speed of gun.

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13. A projectile of mass 3m is projected from ground with velocity $20\sqrt{2}m/s$ at 45°. At highest point it explodes into two pieces. One of mass 2m and the other of mass m. Both the pieces fly off horizontally in opposite directions. Mass 2m falls at a distance of $100m$ from point of projection. Find the distance of second mass from point of projection where it strikes the ground.

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

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14. (a) A rocket set for vertical firing weighs $50kg$ and contains $450kg$ of fuel. It can have a maximum exhaust velocity of $2km/s$. What should be its minimum rate of fuel consumption

(i) to just lift off the launching pad?

(ii) to give it an initial acceleration of $20m/s^2$?

(b) What will be the speed of the rocket when the rate of consumption of fuel is $10kg/s$ after whole of the fuel is consumed? (Take $g = 9.8m/s^2$)

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15. A ball of mass 200g is projected with a density of $30m/s$ at 30° from horizontal. Using the concept of impulse, find change in velocity in 2s. Take $g=10m/s^2$.

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16. A time varying force, $F=2t$ is acting on a particle of mass $2kg$ moving along x-axis. velocity of the particle is $4m/s$ along negative x-axis at time $t = 0$. Find the velocity of the particle at the end of 4s.

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17. A particle of mass $2kg$ is initially at rest. A force starts acting on it in one direction whose magnitude changes with time. The force time graph is shown in figure. Find the velocity of the particle at the end of $10s$.

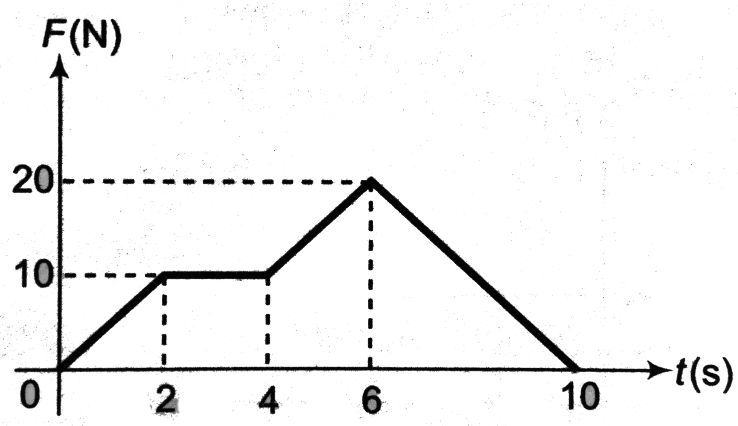

Fig. 11.29

A. 10

B. 30

C. 40

D. 50

Answer: D

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18. A bullet of mass $10^{-3} kg$ strikes an obstacle and moves at 60° to its original direction. If its speed also changes from $20 m/s$ to $10 m/s$. Find the magnitude of impulse acting on the bullet.

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19. Two blocks A and B of equal mass $m = 1.0 kg$ are lying on a smooth horizontal surface as shown in figure. A spring of force constant $k = 200 N/m$ is fixed at one end of block A. Block B collides with block A with velocity $v_0 = 2.0 m/s$. Find the maximum compression of the spring.

20. Two balls of masses m and 2m moving in opposite directions collide head on elastically with velocities v and $2v$. Find their velocities after collision.

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21. Two pendulum bobs of masses m and $2m$ collide head on elastically at the lowest point in their motion. If both the balls are released from a height H above the lowest point, to what heights do they rise for the first time after collision?

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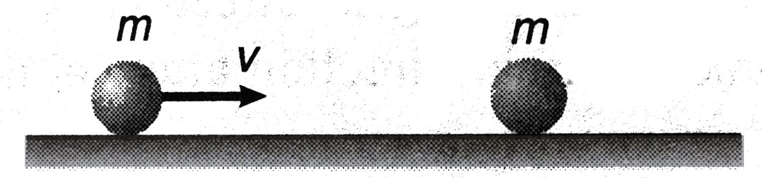
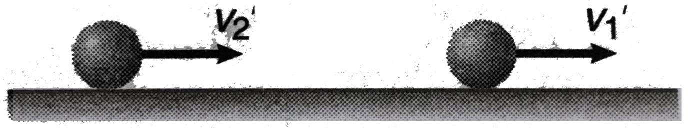
22. A ball of mass m moving at a speed v makes a head on inelastic collision with an identical ball at rest. The kinetic energy of the balls after the collision is $\frac{3}{4}th$ of the original. Find the coefficient of restitution.





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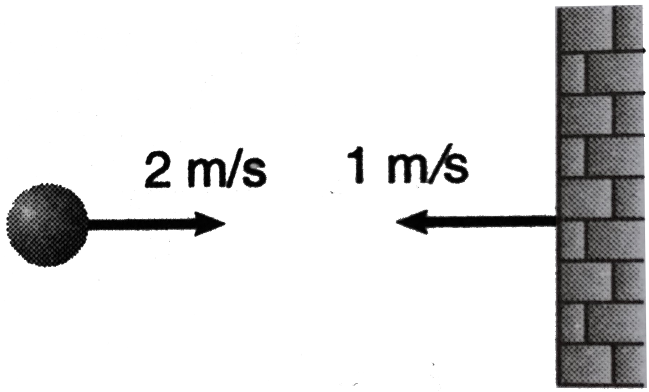
23. A ball is moving with velocity $2m/s$ towards a heavy wall moving towards the ball with speed $1m/s$ as shown in figure.

Assuming collision to be elastic, find the velocity of ball immediately after the collision.



A. $v = 4m / s$

B. $v = 3m / s$

C. $v = 0m / s$

D. $v = 1m / s$

Answer: A

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24. A ball of mass m hits a floor with a speed v_0 making an angle of incidence α with the normal. The coefficient of restitution is e. Find the speed of the reflected ball and the angle of reflection of the ball.

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25. After a completely inelastic collision two objects of the same mass and same initial speed are found to move away together at half their initial speed. Find the angle between the initial velocities of the objects.

A. 120°

B. 90°

C. 180°

D. 60°

Answer: A

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26. The coefficient of restitution between a snooker ball and the side cushion is $\frac{1}{3}$. If the ball hits the cushion and then rebounds at right angles to its original direction, show that the angles made with the side cushion by the direction of motion before and after impact are 60° and 30° respectively.

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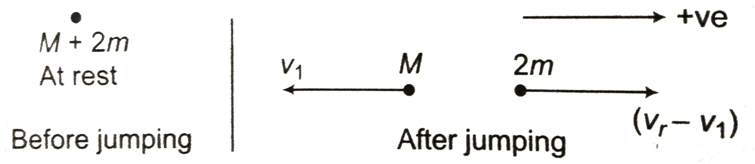
Solved Examples

1. A trolley of mass M is at rest over a smooth horizontal surface as shown in figure. Two boys each of mass 'm' are standing over the trolley. They jump from the trolley (towards right) with relative velocity v_r [relative to velocity of trolley just after jumping]

(a) together

(b) one after the other.

Find velocity of trolley in both cases.



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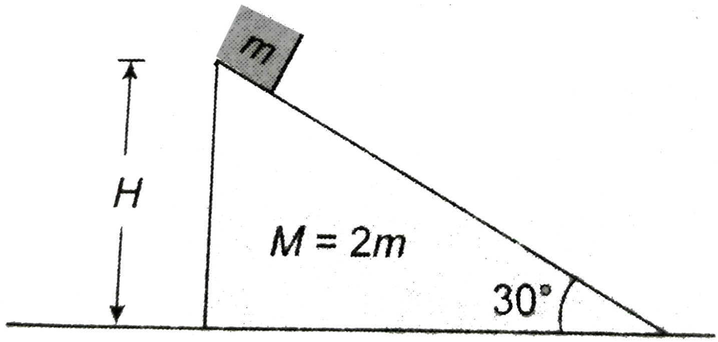
2. A block of mass m is placed on a triangular block of mass $M(M = 2m)$, as shown. All surfaces are smooth. Calculate the velocity of triangular block when the smaller block reaches at bottom.



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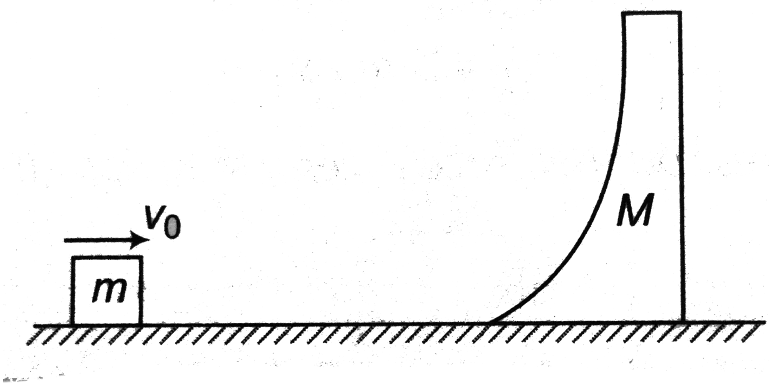
3. All surfaces shown in figure are smooth. Wedges of mass 'M' is free to move. Block of mass 'm' is given a horizontal velocity v_0 as shown. Find the maximum height 'h' attained by 'm' (over the wedges or outside it).



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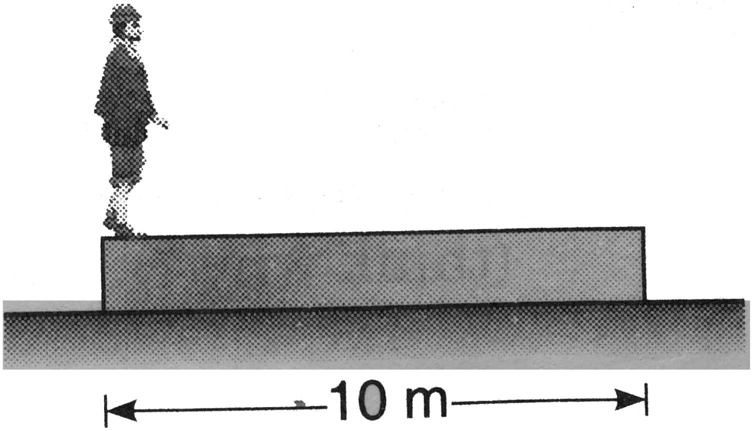
4. A wooden plank of mass $20kg$ is resting on a smooth horizontal floor. A man of mass $60kg$ starts moving from one end of the plank to the other end. The length of the plank is $10m$.

Find the displacement of the plank over the floor when the man reaches the other end of the plank.



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5. A man of mass m_1 is standing on a platform of mass m_2 kept on a smooth horizontal surface. The man starts moving on the platform with a velocity v_r relative to the platform. Find the recoil velocity of platform.

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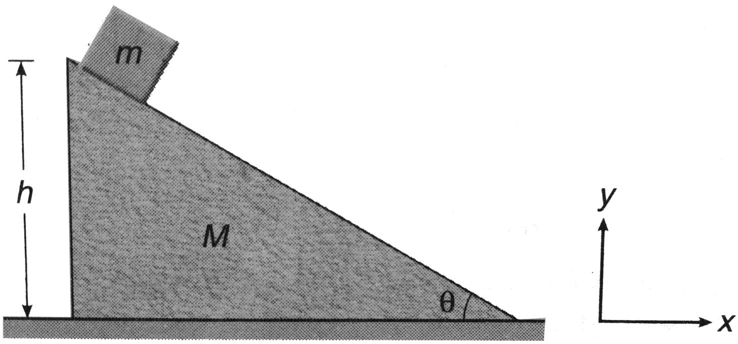
6. A block of mass m is released from the top of a wedge of mass M as shown in figure. Find the displacement of wedges on the horizontal ground when the block reaches the bottom of the wedges. Neglect friction everywhere.



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7. A bomb of mass '5m' at rest explodes into three parts of masses $2m$, $2m$ and m. After explosion, the equal parts move at right angles with speed v each. Find speed of the third part and total energy released during explosion.

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8. A projectile of mass $3kg$ is projected with velocity $50m/s$ at 37° from horizontal. After $2s$, explosion takes place and the projectile breaks into two parts of masses $1kg$ and $2kg$. The first part comes to rest just after explosion.

Find,

(a) the velocity of second part just after explosion.

(b) maximum height attained by this part. Take $g = 10m / s^2$

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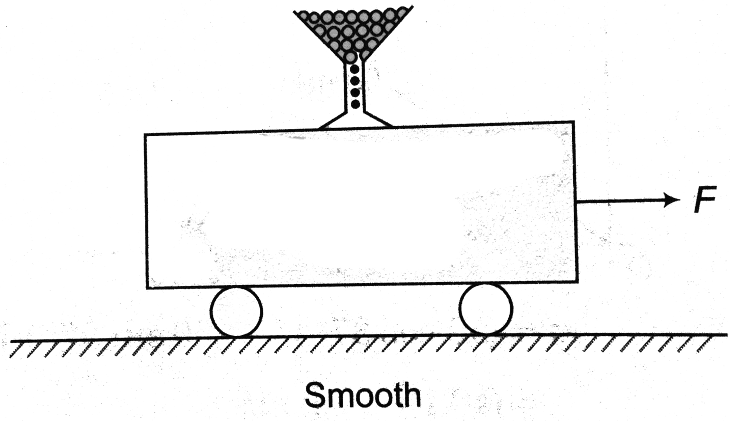
9. A constant force F is applied on a trolley of initial mass m_0 kept over a smooth surface. Sand is poured gently over the trolley at a constant rate of (μ)kg//s`. Afer time t, find



(a) mass of the trolley (with sand)

(b) net force on the trolley

(c) velocity of trolley

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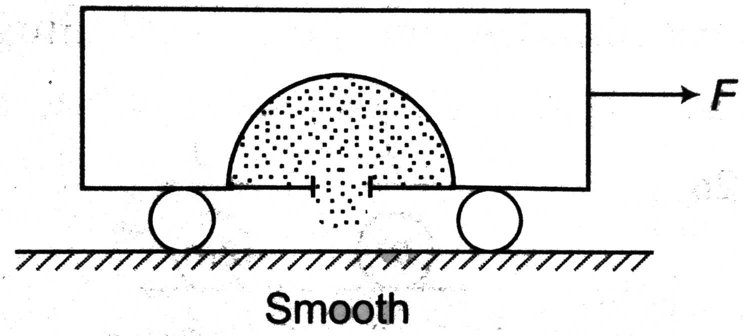
10. A trolley of initial mass m_0 is kept over a smooth surface as shown in figure. A constant force F is applied on it. Sand kept inside the trolley drains out from its floor at a constant rate of $(\mu)kg/s$. After time t find:



(a) total mass of trolley and sand.

(b) net force on the trolley.

(c) velocity of trolley.

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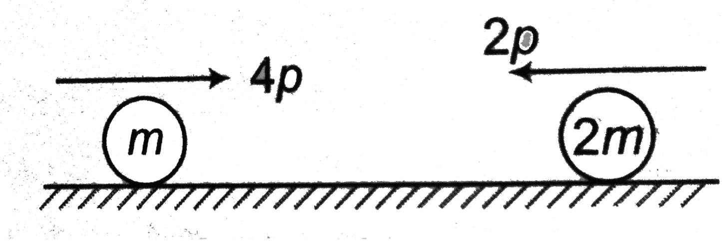
11. Two balls of masses m and $2m$ and momenta $4p$ and $2p$ (in the directions shown) collide as shown in figure. During collsion, the value of linear impulse between them is J. In terms of J and p find coefficient of restitution 'e'. Under what condition collision is elastic. Also find the condition of perfectly inelastic collision.



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12. In the situation discussed above, find

(a) velocity of combined mass just after collision at the bottommost point $(\text{ or } u)$.

(b) loss of mechanical energy during collision.

(c) minimum value of v_0 so that the combined mass completes the vertical circular motion.

13. A pendulum bob of mass $10^{-2} kg$ is raised to a height $5 \times 10^{-2} m$ and then released. At the bottom of its swing, it picks up a mass $10^{-3} kg$. To what height will the combined mass rise?

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Type 1

1. Two toy trains each of mass 'M' are moving in opposite directions with velocities v_1 and v_2 over two smooth rails. Two stuntmen of mass 'm' each are also moving with the trains (at rest w.r.t. trains). When trains are opposite to each other the stuntmen interchange their positions, then find the final velocities of the trains.

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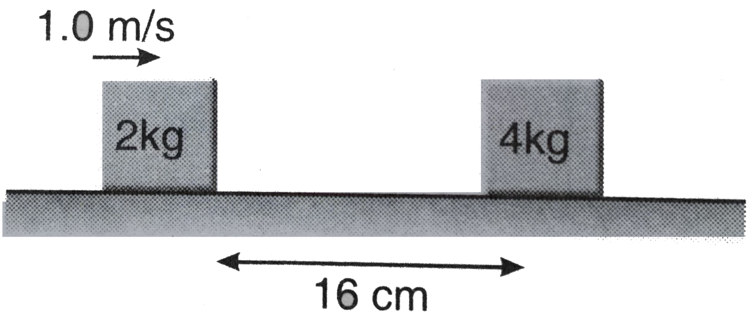
MiscellaneousExamples

1. The friction coefficient between the horizontal surface and each of the block shown in the figure is 0.2. The collision between the blocks is perfectly elastic. Find the separation between them when they come to rest. (Take $g = 10 m/s^2$).



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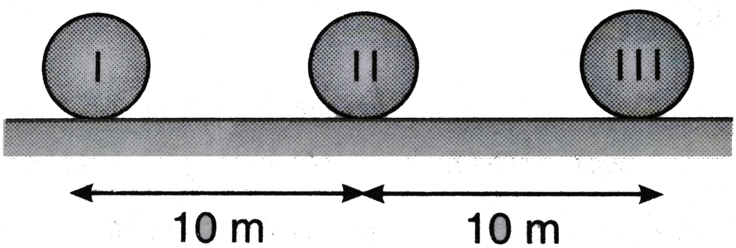
2. Three identical balls, ball I, ball II and ball III are placed on a smooth floor on a straight line at the separation of $10m$ between balls as shown in figure. Initially balls are stationary. But I is given velocity of $10m/s$ towards ball II, collision between balls I and II is inelastic with coefficient of restitution 0.5 but collision between balls II and III is perfectly elastic. What is the time interval between two consecutive collisions between ball I and II?



A. 4s

B. 5s

C. 1s

D. 10s

Answer: A

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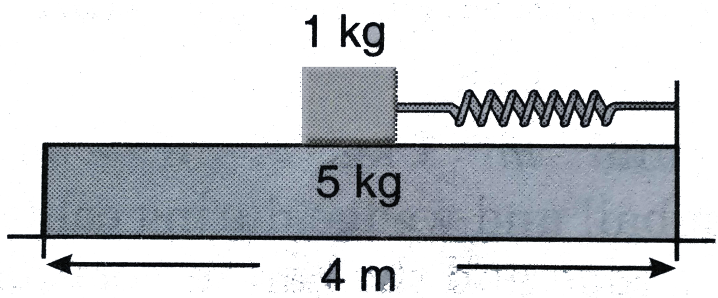
3. A planck of mass $5kg$ is placed on a frictionless horizontal plane. Further a block of mass $1kg$ is placed over the plank. A massless spring of natural length $2m$ is fixed to the plank by its one end. The other end of spring is compressed by the block by half of spring's natural length. They system is now released from the rest. What is the velocity of the plank when block leaves the plank? (The stiffness constant of spring is $100N/m$)



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4. A ball is projected from the ground with speed u at an angle α with horizontal. It collides with a wall at a distance a from the point of projection and returns to its original position. Find the coefficient of restitution between the ball and the wall.

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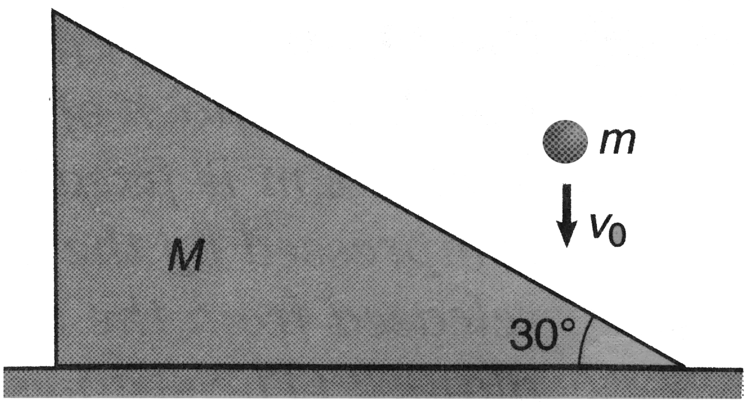
5. A ball of mass $m = 1kg$ falling vertically with a velocity $v_0 = 2m/s$ strikes a wedge of mass $M = 2kg$ kept on a smooth, horizontal

surface as shown in figure. If impulse between ball and wedge during collision is J. Then make two equations which relate J with velocity components of wedge and ball. Also find impulse on wedges from ground during impact.



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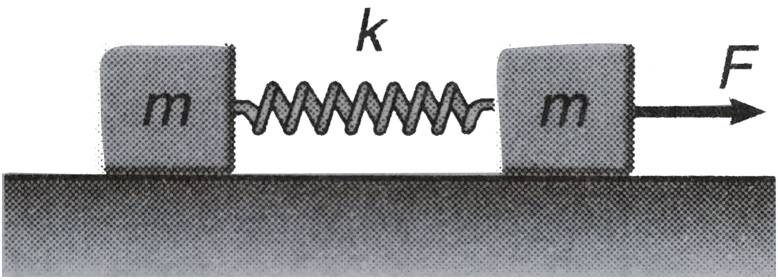
6. Two blocks of equal mass m are connected by an unstretched spring and the system is kept at rest on a frictionless horizontal surface. A constant force F is applied on one of the blocks pulling it away from the other as shown in figure. (a) Find the displacement of the centre of mass at time t. (b) If the extension of the spring is x_0 at time t, find the displacement of the two blocks at this instant.



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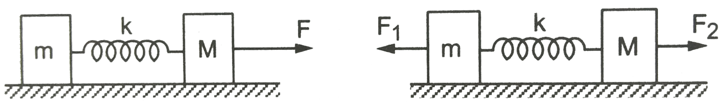
7. A block of mass m is connect to another block of mass M by a massless spring of spring constant k. The blocks are kept on a smooth horizontal plane. Initially the blocks are at rest and the spring is unstretched when a constant force F starts acting on the block of mass M to pull it. Find the maximum extension of the spring.



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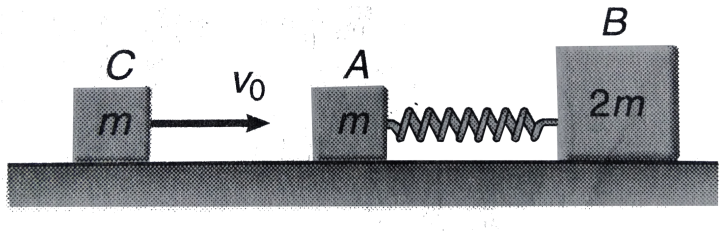
8. Two blocks A and B of masses m and 2m respectively are placed on a smooth floor. They are connected by a spring. A third block C of mass m moves with a velocity v_0 along the line joing A and B and collides elastically with A, as shown in figure. At a certain instant of time t_0 after collision, it is found that the instantaneous velocities of A and B are the same. Further, at this instant the compression of the spring is found to be x_0. Determine (i) the common velocity of A and B at time t_0, and

(ii) the spring constant.



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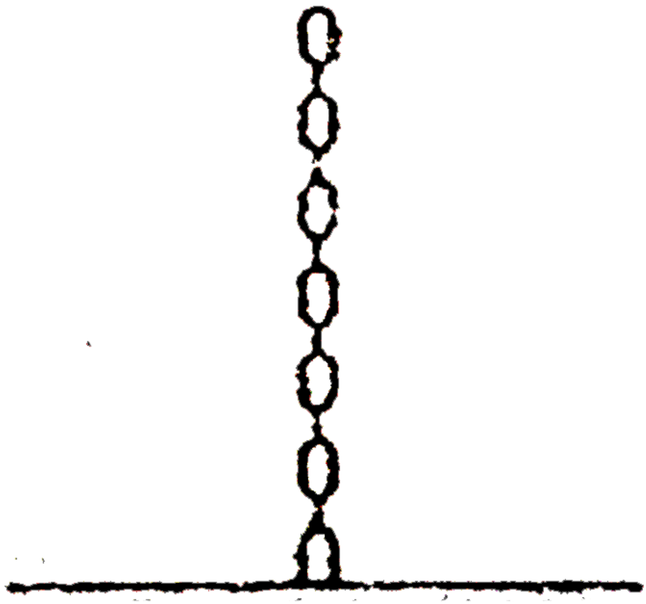
9. A uniform chain of mass m and length l hangs on a thread and touches the surface of a table by its lower end. Thread breaks suddenly. Find the force exerted by the table on the chain when half of its length has fallen on the table. The fallen part does not form heap



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

B. mg

C. 0

D. $\frac{5}{2}mg$

Answer: A

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Exercise 11.1

1. What is the difference between centre of mass and centre of gravity?

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2. The centre of mass of a rigid body always lies inside the body, Is this statement true or false?

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3. The centre of mass always lies on the axis of symmetry if it exists. Is this statement true or false?

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4. If all the particles of a system lie in y-z plane, the x-coordinate of the centre of mass will be zero. Is this statement true or false?

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5. What can be said about the centre of mass of a solid hemisphere of radius r without making any calculation. Will its distance from the centre be more than $r/2$ or less than $r/2$?

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6. All the particles of body are situated at a distance R from the origin. The distance of the centre of mass of the body from the origin is also R. Is this statement true or false?

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7. Three particles of masses $1kg$, $2kg$ and $3kg$ are placed at the corners A, B and C respectively of an equilateral triangle ABC of

edge $1m$. Find the distance of their centre of mass from A.

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8. Find the centre of mass of a uniform plate having semicircular inner and outer boundaries of radii R_1 and R_2.

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9. Find the position of centre of mass of the section shown in figure

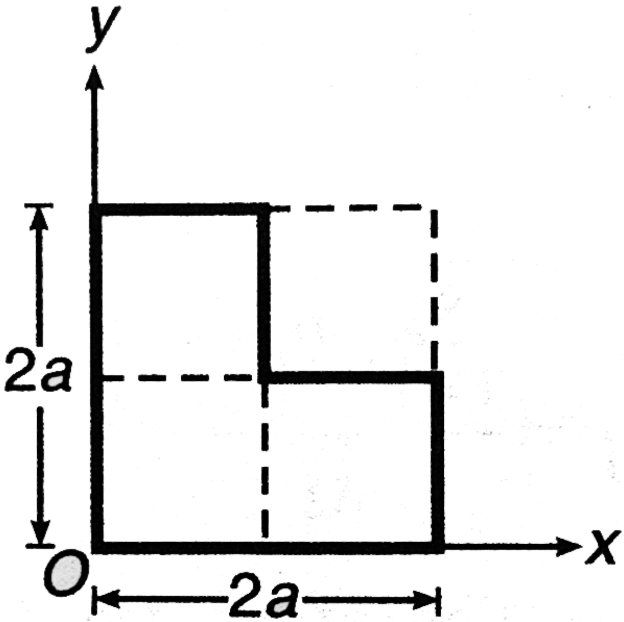

Fig. 11.14

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10. Four particles of masses $1kg$, $2kg$, $3kg$ and $4kg$ are placed at the four vertices A,B,C and D of a square of side $1m$. Find square of distance of their centre of mass from A.

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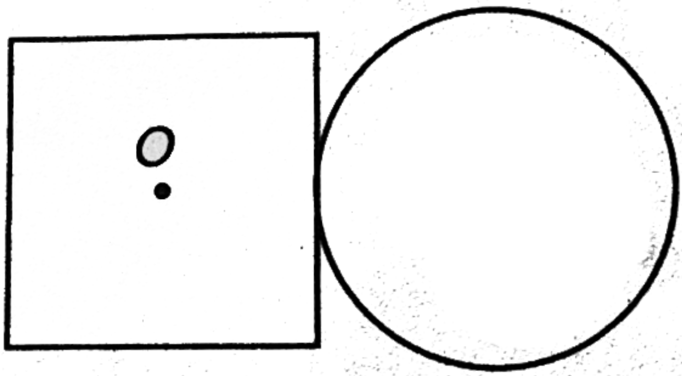
11. A square lamina of side a and a circular lamina of diameter a are placed touching each other as shown in figure. Find distance of their centre of mass from point O, the centre of sqaure.



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12. The density of a thin rod of length l varies with the distance x from one end as

$\rho = \rho_0 \frac{x^2}{l^2}$. Find the position of centre of mass of rod.

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13. A straight rod of length L has one of its end at the origin and the other at $X = L$. If the mass per unit length of the rod is given by Ax where A is constant, where is its centre of mass?

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Exercise 11.2

1. A block of mass $1kg$ is at $x = 10m$ and moving towards negative $x - a\xi s$ with velocity $6m/s$. Another block of mass $2kg$ is at $x = 12m$ and moving towards positive $x -$ axis with velocity $4m/s$ at the same instant. Find position of their centre of mass after $2s$.

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2. Two particles of masses $1kg$ and $2kg$ respectively are initially $10m$ aprt. At time $t = 0$, they start moving towards each other with uniform speeds $2m/s$ and $1m/s$ respectively. Find the displacement of their centre of mass at $t = 1s$.

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3. There are two masses m_1 and m_2 placed at a distance l apart. Let the centre of mass of this system is at a point named C. If m_1 is displaced by l_1 towards C and m_2 is displaced by l_2 away from C. Find the distance, from C where new centre of mass will be located.

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4. At one instant, the centre of mass of a system of two particles is located on the x-axis at $x = 3.0m$ and has a velocity of $(6.0m/s)\hat{j}$. One of the particles is at the origin, the other particle has a mass of $0.10kg$ and is at rest on the $x-$ axis at $x = 12.0m$.

(a) What is the mass of the particle at the origin?

(b) Calculate the total momentum of this system.

(c) What is the velocity of the particle at the origin?

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5. A stone is dropped at $t = 0$. A second stone, will twice the mass of the first, is dropped from the same point at $t = 100ms$.

(a) How far below the release point is the centre of mass of the two stones at $t = 300ms$?(Neither stone has yet reached at groung).

(b) How fast is the centre of the mass of the two-stone system moving at that time?

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6. Two blocks A and B of equal masses are attached to a string passing over a smooth

pulley fixed to a wedge as shown in figure. Find the magnitude of acceleration of centre of mass of the two blocks when they are released from rest. Neglect friction.

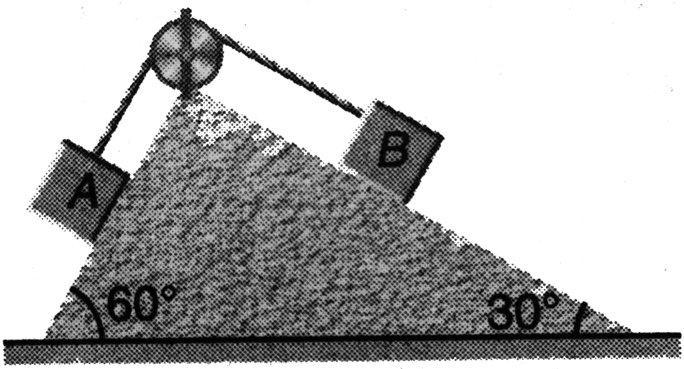

Fig. 11.23

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Exercise 11.3

1. Three particles of masses $20g$, $30g$ and $40g$ are initially moving along the positive direction of the three coordinate axes respectively with the same velocity of $20cm/s$. When due to their mutual interaction, the first particle comes to rest, the second acquires a velocity $\left(10\hat{i} + 20\hat{k}\right)cm/s$. What is then the velocity of the third particle?

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2. A boy of mass 25 kg stands on a board of maas 10 kg which in turn is kept on a frictionless horizontal ice surface. The boy maks a jump with a velocity component 5m/s in a horizontal direction with respect to the ice. With what velocity does the board recoil? with what rate are the boy and the board seperating from each other?

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3. Find the ratio of the linear momenta of two particles of masses 1.0 kg and 4.0 kg if their kinetic energies are equal.

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4. A uranium 238 nucleus, initially at rest emits an alpha particle with a speed of $1.4 \times 10^7 \frac{m}{s}$. Calculate the recoil speed of the residual nucleus thorium 234. Assume that the mas of a nucleus is proportional to the mass number.

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5. A man of mass 50 kg starts moving on the earth and acquires speed of 1.8 m/s. With what speed does the earth recoil? Mass of earth = $6 \times 10^{24} kg$.

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6. A man of mass $60kg$ jumps from a trolley of mass $20kg$ standing on smooth surface with

absolute velocity $3m/s$. Find velocity of trolley and total energy produced by man.

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7. A projectile is fired from a gun at an angle of 45° with the horizontal and with a speed of $20m/s$ relative to ground. At the highest point in its flight the projectile explodes into two fragments of equal masses. One fragement, whose initial speed is zero falls vertically. How far from the gun does the other fragment land, assuming a level terrain? Take $g = 10m/s^2$?

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Exercise 11.4

1. A rocket of mass $20kg$ has $180kg$ fuel. The exhaust velocity of the fuel is $1.6km/s$. Calculate the minimum rate of consumption of fuel so that the rocket may rise from the ground. Also, calculate the ultimate vertical speed gained by the rocket when the rate of consumption of fuel is $\left(g = 9.8m / s^2\right)$

(i) $2kg / s$ (ii) $20kg / s$

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2. A rocket, with an initial mass of $1000kg$, is launched vertically upwards from rest under gravity. The rocket burns fuel at the rate of $10kg$ per second. The burnt matter is ejected vertically downwards with a speed of $2000ms^{-1}$ relative to the rocket. If burning ceases after one minute, find the maximum velocity of the rocket. (Take g as constant at $10ms^{-2}$)

A. 1232.6m//s

B. 123.6m//s

C. 12323.6m//s

D. NONE OF THE ABOVE

Answer: A

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3. A rocket is moving vertically upward against gravity. Its mass at time t is $m = m_0 - \mu t$ and it expels burnt fuel at a speed u vertically downward relative to the rocket. Derive the equation of motion of the rocket but do not solve it. Here, μ is constant.

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4. A rocket of initial mass m_0 has a mass $m_0(1 - t/3)$ at time t. The rocket is lauched from rest vertically upwards under gravity and expels burnt fuel at a speed u relative to the rocket vertically downward. Find the speed of rocket at $t = 1$.

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Exercise 11.5

1. A truck of mass $2 \times 10^3 kg$ travelling at $4m/s$ is brought to rest in $2s$ when it strikes a wall. What force (assume constant) is exerted by the wall?

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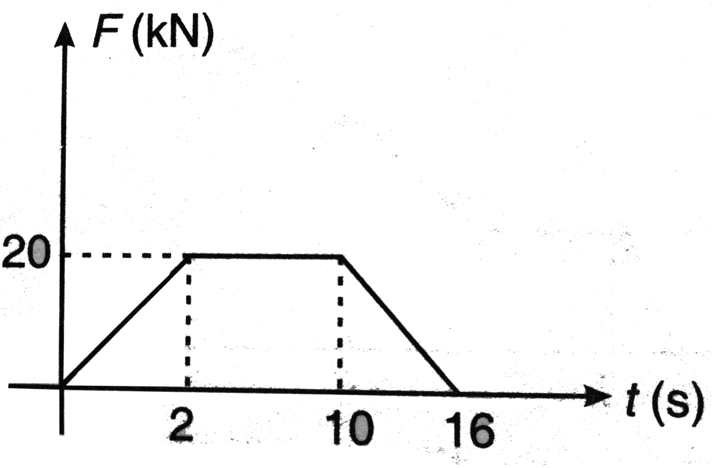
2. A ball of mass m, travelling with velocity $2\hat{i} + 3\hat{j}$ receives an impulse $-3m\hat{i}$. What is the velocity of the ball immediately afterwards?

Watch Video Solution

3. The net force versus time graph of a rocket is shown in figure The mass of the rocket is $1200kg$. Calculate velocity of rocket, 16 seconds after starting from rest. Neglect gravity.



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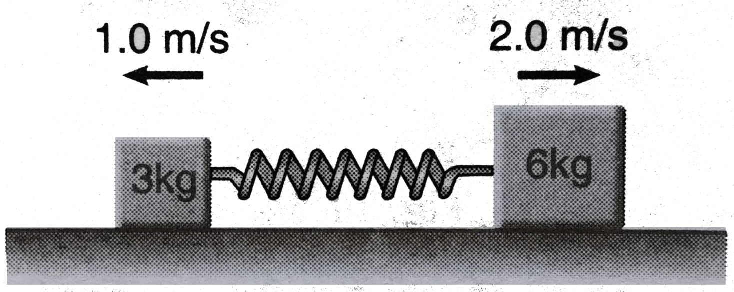
4. A $5.0g$ bullet moving at $100m/s$ strikes a log. Assume that the bullet undergoes uniform deceleration and stops in $6.0cm$. Find (a) the time taken for the bullet to stop, (b) the impulse on the log and (c) the average force experienced by the log.

Watch Video Solution

Exercise 11.6

1. Two blocks of masses $3kg$ and $6kg$ respectivley are placed on a smooth horizontal surface. They are connected by a light spring of force constant $k = 200N/m$. Initially the spring is unstretched. The indicated velocities are imparted to the blocks. Find the maximum extension of the spring.



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2. A moving body of mass m makes a head on elastic collision with another body of mass $2m$ which is initially at rest. Find the fraction of kinetic energy lost by the colliding particles after collision.

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3. What is the fractional decrease in kinetic energy of a body of mass m_1 when it makes a head on elastic collision with another body of mass m_2 kept at rest?

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4. In one dimensional elastic collison of equla masses, the velocities are interchanged. Can velocities ina one dimensional collision be interchanged if the masses are not equal?

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5. After an head on elastic collision between two balls of equal masses, one is observed to have a speed of $3m/s$ along the positive x-axis and the other has a speed of $2m/s$ along the negative x-axis. What are the original velocities of the balls?

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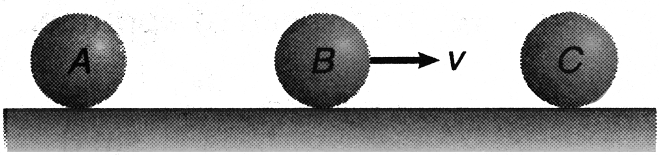
6. A ball of mass $1kg$ moving with $4m^{-1}$ along +x-axis collides elastically with an another ball of mass $2kg$ moving with $6m/s$ is opposite direction. Find their velocities after collision.

Watch Video Solution

7. Three balls A, B and C are placed on a smooth horizontal surface. Given that $m_A = m_C = 4m_B$. Ball B collides with ball C with an initial velocity v as shown in figure. Find the total number of collisions between the balls. All collisions are elastic.



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8. Ball 1 collides directly with another identical ball 2 at rest. Velocity of second ball becomes two times that of 1 after collison. Find the coefficient of restitution between the two balls?

Watch Video Solution

9. A sphere A of mass m, travelling with speed v, collides directly with a stationary sphere B. If A is brought to rest and B is given a speed V, find (a) the mass of B (b) the coefficient of restitution between A and B?

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10. A smooth sphere is moving on a horizontal surface with velocity vector $2\hat{i} + 2\hat{j}$ immediately before it hits a vertical wall. The wall is parallel to $\hat{j}$ and the coefficient of restitution of the sphere and the wall is $e = \frac{1}{2}$. Find the velocity of the sphere after it hits the wall?

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11. A ball falls vertically on an inclined plane of inclination α with speed v_0 and makes a perfectly elastic collision. What is angle of velocity vector with horizontal after collision.

Watch Video Solution

Level 1 Assertion And Reason

1. Assertion: Centre of mass of a rigid body always liees inside the body.

Reason: Centre of mass and centre of gravity coincide if gravity is uniform.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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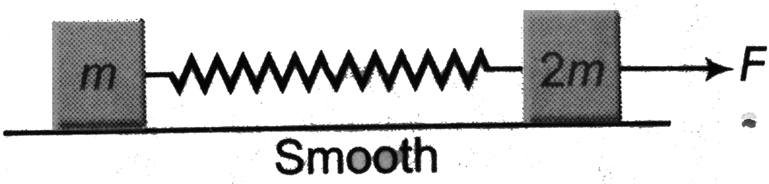
2. Assertion: A constant force F is applied on two blocks and one spring system as shown in figure. Velocity of centre of mass increases linearly with time.



Reason: Acceleration of centre of mass is constant.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A

Watch Video Solution

3. Assertion: To conserve linear momentum of a system, no force should act on the system.

Reason: If net force on a system is zero, its linear momentum should remain constant.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

Watch Video Solution

4. Assertion: A rocket moves forward by pushing the surrounding air backwards.

Reason: It derives the necessary thrust to move forward according to Newton's third law of motion.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

Watch Video Solution

5. Assertion: Internal forces cannot change linear momentum.

Reason: Internal forces can change the kinetic energy of a system.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: B

Watch Video Solution

6. Assertion: In case of bullet fired from gun, the ration of kinetic energy of gun and bullet is equal to ration of mass of bullet and gun.

Reason: Kinetic energy $\propto \frac{1}{mass}$, if momentum is constant.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of

the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

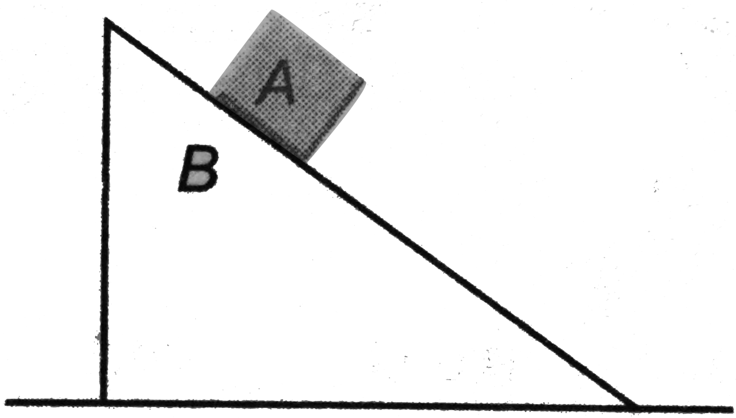
C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A

Watch Video Solution

7. Assertion: All surfaces shown in figure are smooth. System is released from rest. Momentum of system in horizontal direction is constant but overall momentum is not constant.



Reason: A net vertically upward force is acting on the system.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: C

Watch Video Solution

8. Assertion: During head on collision between two bodies let Δp_1 is change in momentum of first body and Δp_2 the change in momentum of the other body, then $\Delta p_1 = \Delta p_2$.

Reason: Total momentum of the system should remain constant.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

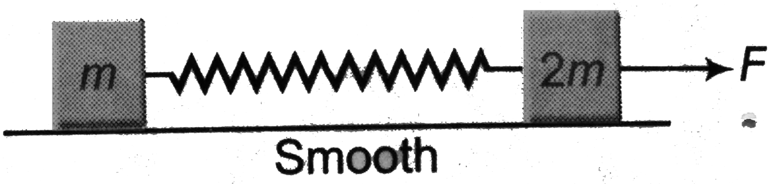
C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

Watch Video Solution

9. Assertion: In the sytem shown in figure spring is first stretched then left to oscillate. At some instant kinetic energy of mass m is K. At the same instant kinetic energy of mass $2m$ should be $\frac{K}{2}$.



Reason: Their linear momenta are equal and opposite and $K = \frac{p^2}{2m}$ or $K = \frac{1}{m}$.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A

View Text Solution

10. Assertion: Energy can not be given to a system without giving it momentum.

Reason: If kinetic energy is given to a body it means it has acquired momentum.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

Watch Video Solution

11. Assertion: The centre mass of an electron and proton, when released moves faster towards proton.

Reason: Proton is heavier than electron.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

Watch Video Solution

12. Assertion: The relative velocity of the two particles in head-on elastic collision is unchanged both in magnitude and direction.

Reason: The relative velocity is unchanged in magnitude but gets reversed in direction.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of

the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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13. Assertion: An object of mass m_1 and another of mass $m_2 (m_2 > m_1)$ are released from certain distance. The objects move towards each other under the gravitational force between them. In this motion, centre of mass of their system will continuously move towards the heavier mass m_2.

Reason: In a system of a heavier and a lighter mass, centre of mass lies closer to the heavier mass.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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14. Assertion: A given force applied in turn to a number of different masses may cause the same rate of change in momentum in each but not the same acceleration to all.

Reason: $F = \frac{dp}{dt}$ and $a = \frac{F}{m}$

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of

the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A

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15. STATEMENT-I : In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

STATEMENT-2 : In an elastic collision, the linear momentum of the system is conserved.

A. (a) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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Level 1 Objective

1. A ball is dropped from height 10 m . Ball is embedded in sand 1 m and stops, then

A. (a) only momentum remains conserved

B. (b) only kinetic energy remains conserved

C. (c) both momenutm and kinetic energy are conserved

D. (d) neither kinetic energy nor momentum is conserved

Answer: A

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2. If no external force acts on a system

A. (a) velocity of centre of mass remains constant

B. (b) position of centre of mass remains constant

C. (c) acceleration of centre of mass remains non-zero and constant

D. (d) All of the above

Answer: A

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3. When two blocks connected by a spring move towards each other under mutual interaction

A. (a) their velocities are equal

B. (b) their accelerations are equal

C. (c) the force acting on them are equal and opposite

D. (d) All of the above

Answer: C

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4. If two balls collide in air while moving vertically, then momentum of the sytem is conserved because

A. gravity does not affect the momentum of the system

B. force of gravity is very less compared to the impulsive force

C. impulsive force is very less than the gravity

D. gravity is not acting during collision

Answer: B

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5. When a cannon shell explodes in mid air, then identify the incorrect statement

A. (a) the momentum of the system is conserved at the time of explosion

B. (b) the kinetic energy of the system always increases

C. (c) the trajectory of centre of mass remains unchanged

D. (d) None of the above

Answer: B

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6. In an inelastic collision

A. (a) momentum of the system is always conserved

B. (b) velocity of separation is less than the velocity of approach.

C. (c) the coefficient of restitution can be zero

D. (d) All of the above

Answer: D

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7. The momentum of a system is defined

A. (a) as the product of mass of the system and the velocity of centre of mass

B. (b) as the vector sum of the momentum of individual particles

C. (c) for bodies undergoing translational, rotational and oscillatory motion

D. (d) all the above

Answer: D

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8. The momentum of a system with respect to centre of mass

A. (a) is zero only if the system is moving uniformly

B. (b) is zero only if no external force acts on the system

C. (c) is always zero

D. (d) can be zero in certain conditions

Answer: C

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9. Three identical particles are located at the vertices of an equilateral triangle. Each particle moves along a meridian with equal speed towards the centroid and collides inelastically.

A. (a) all the three particles will bounce back along the meridians with lesser speed.

B. (b) all the three particles will become stationary.

C. (c) all the particles will continue to move in their original directions but with lesser speed

D. (d) nothing can be said

Answer: D

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10. The average resisting force that must act on $5kg$ mass to reduce its speed from 65 to $15ms^{-1}$ in $2s$ is

A. $12.5N$

B. $125N$

C. $1250N$

D. None of these

Answer: B

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11. In a carbon monoxide molecule, the carbon and the oxygen atoms are separated by a distance $1.2 \times 10^{-10} m$. The distance of the centre of mass from the carbon atom is

A. $0.48 \times 10^{-10} m$

B. $0.51 \times 10^{-10} m$

C. $0.74 \times 10^{-10} m$

D. $0.68 \times 10^{-10} m$

Answer: D

Watch Video Solution

12. A bomb of mass $9kg$ explodes into two pieces of masses $3kg$ and $6kg$. The velocity of mass $3kg$ is $16ms^{-1}$. The kinetic energy of mass $6kg$ is

A. $96J$

B. $384J$

C. $192J$

D. $768J$

Answer: C

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13. A heavy ball moving with speed v collides with a tiny ball. The collision is elastic, then immediately after the impact, the second ball will move with a speed approximately equal to

A. (a) v

B. (b) $2v$

C. (c) $\frac{v}{2}$

D. (d) $\frac{v}{3}$

Answer: B

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14. A loaded $20,000kg$ coal wagon is moving on a level track at $6ms^{-1}$. Suddenly $5000kg$ of coal is dropped out of the wagon. The final speed of the wagon is

A. $6ms^{-1}$

B. $8ms^{-1}$

C. $4.8ms^{-1}$

D. $4.5ms^{-1}$

Answer: A

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15. A machine gun fires a bullet of mass 40 g with a velocity $1200ms^{-1}$. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can be fire per second at the most?

A. (a) 3

B. (b) 5

C. (c) 6

D. (d) 9

Answer: A

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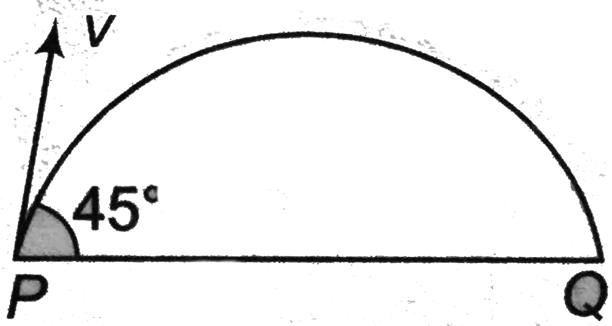
16. A projectile of mass m is fired with a velocity v from point P at an angle 45°. Neglecting air resistance, the magnitude of the change in momentum leaving the point P and arriving at Q is



A. (a) $\sqrt{2}mv$

B. (b) $2mv$

C. (c) $\frac{mv}{2}$

D. (d) $\frac{mv}{\sqrt{2}}$

Answer: A

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17. A ball after freely falling from a height of $4.9m$ strikes a horizontal plane. If the coefficient of restitution is $\frac{3}{4}$, the ball will strike second time with the plane after

A. $\frac{1}{2}s$

B. $1s$

C. $\frac{3}{2}s$

D. $\frac{3}{4}s$

Answer: C

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18. The centre of mass of a non uniform rod of length L, whose mass per unit length varies as

$\rho = \frac{k.\,x^2}{L}$ where k is a constant and x is the distance of any point from one end is (from the same end)

A. $\left(\frac{3}{4}\right)L$

B. $\left(\frac{1}{4}\right)L$

C. $\left(\frac{1}{6}\right)L$

D. $\left(\frac{2}{3}\right)L$

Answer: A

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19. A boat of length $10m$ and mass $450kg$ is floating without motion in still water. A man of mass $50kg$ standing at one end of it walks to the other end of it and stops. The magnitude of the displacement of the boat in metres relative to ground is

A. (a) zero

B. (b) $1m$

C. (c) $2m$

D. (d) $5m$

Answer: B

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20. A man of mass M stands at one end of a stationary plank of length L, lying on a smooth surface. The man walks to the other end of the plank. If the mass of the plank is $M/3$, the distance that the man moves relative to the ground is

A. $\frac{3L}{4}$

B. $\frac{L}{4}$

C. $\frac{4L}{5}$

D. $\frac{L}{3}$

Answer: B

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21. A ball of mass m moving at a speed v collides with another ball of mass $3m$ at rest. The lighter block comes to rest after collisoin. The coefficient of restitution is

A. (a) $\frac{1}{2}$

B. (b) $\frac{2}{3}$

C. (c) $\frac{1}{4}$

D. (d) None of these

Answer: D

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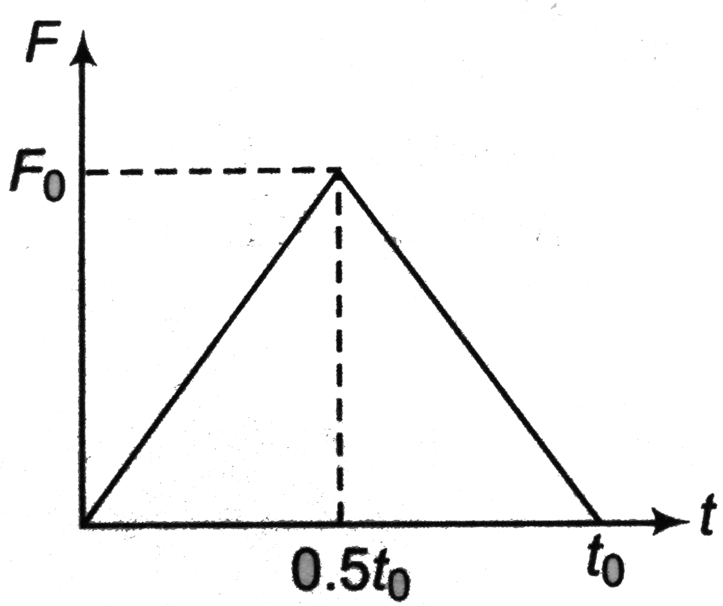
22. A particle of mass m moving with velocity u makes an elastic one-dimensional collision with a stationary particle of mass m. They come in contact for a very small time t_0. Their force of interaction increases from zero to F_0 linearly in time $0.5t_0$, and decreases linearly to zero in further time $0.5t_0$ as shown in figure. The magnitude of F_0 is



A. $\frac{\mu}{t_0}$

B. $\frac{2\mu}{t_0}$

C. $\frac{\mu}{2t_0}$

D. None of these

Answer: B

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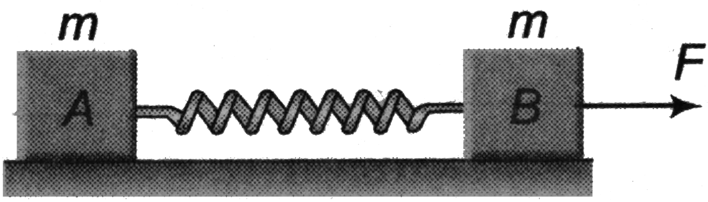
23. Two identical blocks A and B of mass m joined together with a massless spring as shown in figure are placed on a smooth surface. If the block A moves with an acceleration a_0, then the acceleration of the block B is



A. a_0

B. $-a_0$

C. $\frac{F}{m}-a_0$

D. $\frac{F}{m}$

Answer: C

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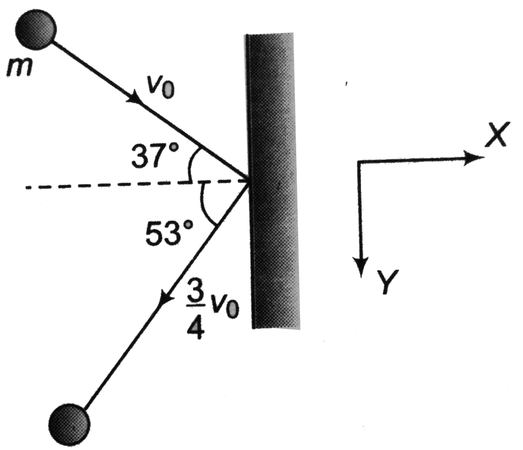
24. A ball of mass m moving with velocity v_0 collides a wall as shown in figure. After impact it rebounds with a velocity $\frac{3}{4}v_0$. The impulse acting on ball during impact is



A. $-\frac{m}{2}v_0\hat{j}$

B. $-\frac{3}{4}mv_0\hat{i}$

C. $\frac{-5}{4}mv_0\hat{i}$

D. None of the above

Answer: C

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25. A steel ball is dropped on a hard surface from a height of $1m$ and rebounds to a height of $64cm$. The maximum height attained by the ball after n^{th} bounce is (in m)

A. (a) $(0.64)^{2n}$

B. (b) $(0.8)^{2n}$

C. (c) $(0.5)^{2n}$

D. (d) $(0.8)^{n}$

Answer: B

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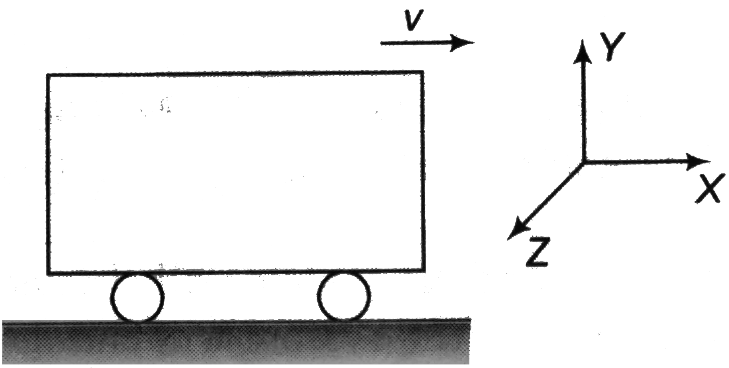
26. A car of mass $500kg$ (including the mass of a block) is moving on a smooth road with velocity $1.0ms^{-1}$ along positive x-axis. Now a block of mass $25kg$ is thrown outside with absolute velocity of $20ms^{-1}$ along positive z-axis. The new velocity of the car is $\left(ms^{-1}\right)$



A. (a) $10\hat{i} + 20\hat{k}$

B. (b) $10\hat{i} - 20\hat{k}$

C. (c) $\frac{20}{19}\hat{i} - \frac{20}{19}\hat{k}$

D. (d) $10\hat{i} - \frac{20}{19}\hat{k}$

Answer: C

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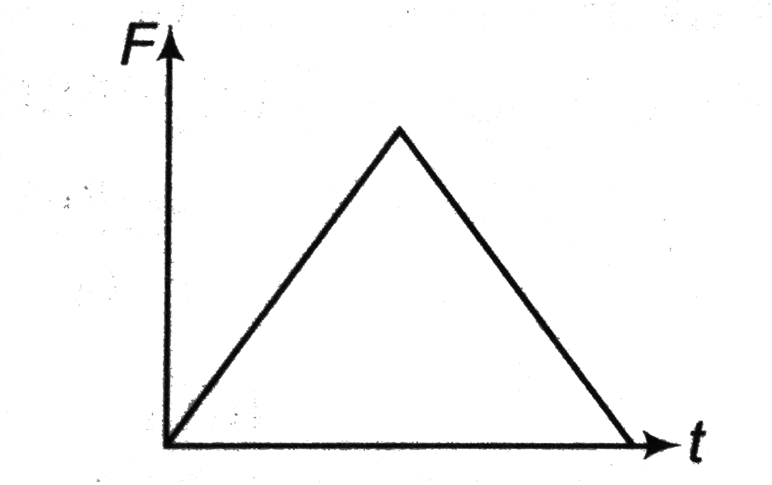
27. The net force acting on a particle moving along a straight line varies with time as shown in the diagram. Force is parallel to velocity. Which of the following graph is best representative of its speed with time? (Initial velocity of the particle is zero)



A. (a)

B. (b)

C. (c)

D. (d)

Answer: A

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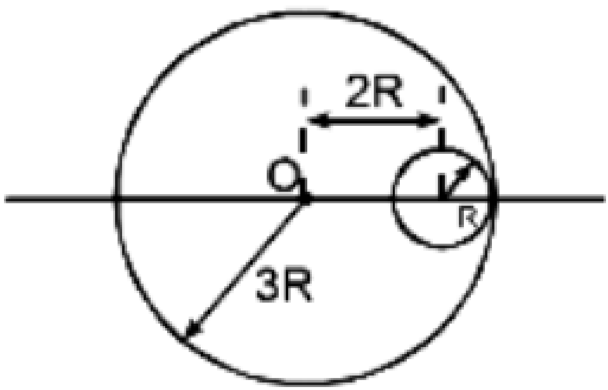
28. In the figure shown, find out centre of mass of a system of a uniform circular plate of radius $3R$ from O in which a hole of radius R is cut whose centre is at $2R$ distance from the centre of large circular plate



A. (a) $\frac{R}{2}$

B. (b) $\frac{R}{5}$

C. (c) $\frac{R}{4}$

D. (d) None of these

Answer: C

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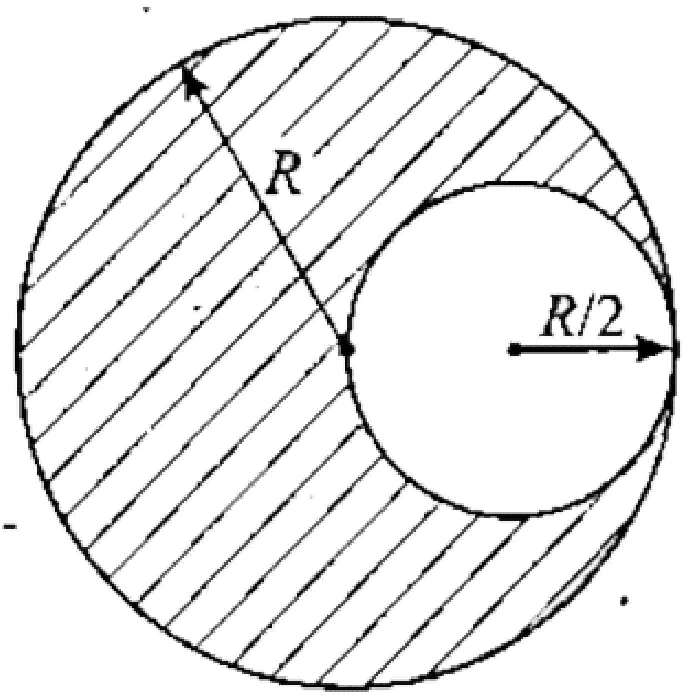
29. From the circular disc of radius $4R$ two small discs of radius R are cut off. The centre of mass of the new structure will be at



A. $\hat{i}\dfrac{R}{5}+\hat{j}\dfrac{R}{5}$

B. (b) $-\hat{i}\dfrac{R}{5}+\hat{j}\dfrac{R}{5}$

C. (c) $-\hat{i}\dfrac{R}{5}-\hat{j}\dfrac{R}{5}$

D. (d) None of the above

Answer: D

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30. A block of mass m rests on a stationary wedge of mass M. The wedge can slide freely on a smooth horizontal surface as shown in figure. If the block starts from rest

A. (a) the position of the centre of mass of the system will change

B. (b) the position of centre of mass of the system will change along the vertical but not along the horizontal

C. (c) the total energy of the system will remain constant

D. (d) All of the above

Answer: D

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31. A bullet of mass m hits a target of mass M hanging by a string and gets embeded in it. If the block rises to a height h as a result of this collision, the velocity of the bullet before collision is

A. $v = \sqrt{2gh}$

B. $v = \sqrt{2gh}\left[1 + \frac{m}{M}\right]$

C. $v = \sqrt{2gh}\left[1 + \frac{M}{m}\right]$

D. $v = \sqrt{2gh}\left[1 - \frac{m}{M}\right]$

Answer: C

Watch Video Solution

32. A loaded spring gun of mass M fires a bullet of mass m with a velocity v at an angle of elevation θ. The gun is initially at rest on a horizontal smooth surface. After firing, the centre of mass of the gun and bullet system

A. (a) moves with velocity $\frac{v}{M}m$

B. (b) moves with velocity $\frac{vm}{m \cos \theta}$ in the horizontal direction

C. (c) does not move in horizontal direction

D. (d) moves with velocity $\dfrac{v(M-m)}{M+m}$ in the horizontal direction

Answer: C

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33. Two bodies with masses m_1 and $m_2 (m_1 > m_2)$ are joined by a string passing over fixed pulley. Assume masses of the pulley and thread negligible. Then the acceleration of the centre of mass of the system $(m_1 + m_2)$

is

A. (a) $\left(\dfrac{m_1 - m_2}{m_1 + m_2}\right)g$

B. (b) $\left(\dfrac{m_1 - m_2}{m_1 + m_2}\right)^2 g$

C. (c) $\dfrac{m_1 g}{m_1 + m_2}$

D. (d) $\dfrac{m_2 g}{m_1 + m_2}$

Answer: B

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34. A rocket of mass m_0 has attained a speed equal to its exhaust speed and that time the mass of the rocket is m. Then the ratio $\frac{m_0}{m}$ is (neglect gravity)

A. (a) 2.718

B. (b) 7.8

C. (c) 3.14

D. (d) 4

Answer: A

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35. A jet of water hits a flat stationary plate perpendicular to its motion. The jet ejects $500g$ of water per second with a speed of $1m/s$. Assuming that after striking, the water flows parallel to the plate, then the force exerted on the plate is

A. (a) $5N$

B. (b) $1.0N$

C. (c) $0.5N$

D. (d) $10N$

Answer: C

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36. Two identical vehicles are moving with same velocity v towards an intersection as shown in figure. If the collision is completely inelastic, then

A. (a) the velocity of separation is zero

B. (b) the velocity of approach is $2vsin\frac{\theta}{2}$

C. (c) the common velocity after collision is $vcos\frac{\theta}{2}$

D. (d) All of the above

Answer: D

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37. A ball of mass $m = 1kg$ strikes a smooth horizontal floor as shown in figure. The impulse exerted on the floor is

A. (a) $6.25 Ns$

B. (b) $1.76 Ns$

C. (c) $7.8 Ns$

D. (d) $2.2 Ns$

Answer: A

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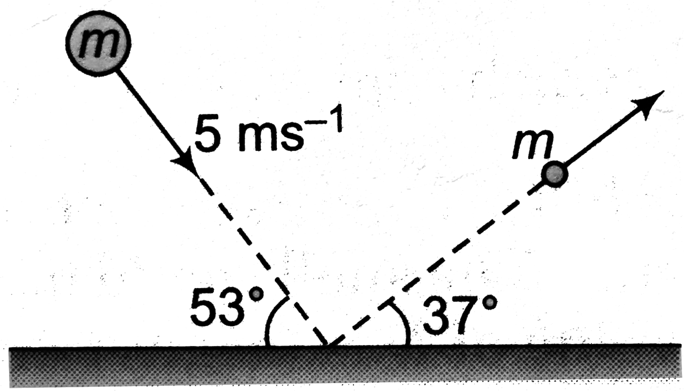
38. A small block of mass m is placed at rest on the top of a smooth wedge of mass M, which in turn is placed at rest on a smooth horizontal surface as shown in figure. It h be the height of wedge and θ is the inclination, then the distance moved by the wedge as the block reaches the foot of the wedge is



A. $\dfrac{Mh\cot\theta}{M+m}$

B. (b) $\dfrac{mh\cot\theta}{M+m}$

C. (c) $\dfrac{Mh\cos ec\theta}{M+m}$

D. (d) $\dfrac{mh\cos ec\theta}{M+m}$

Answer: B

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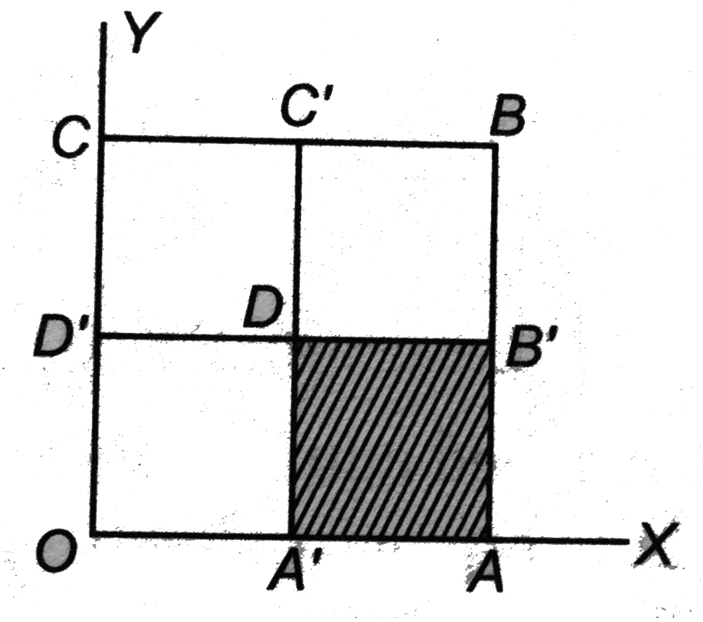
39. A square of side $2cm$ and uniform thickness is divided into four squares. The square portion $A'AB'D$ is removed and the removed portion is placed over the portion $DB'BC'$. The new position of centre of mass is



A. $(2cm, 2cm)$

B. $(2cm, 3cm)$

C. $(2cm, 2.5cm)$

D. $(3cm, 3cm)$

Answer: C

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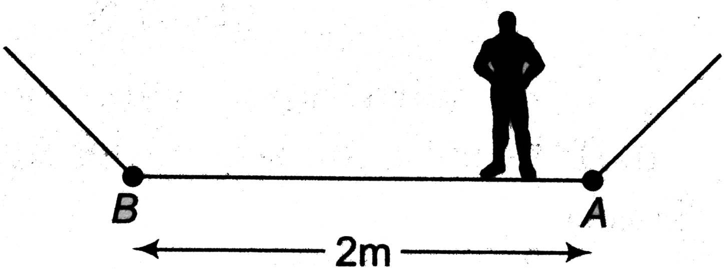
40. A boy having a mass of $40kg$ stands at one end A of a boat of length $2m$ at rest. The boy walks to the other end B of the boat and stops. What is the distance moved by the boat? Friciton exists between the feet of the boy and the surface of the boat. But the friction between the boat and the water surface may be neglected. Mass of the boat is $15 kg$.



A. (a) $0.49 m$

B. (b) $2.46 m$

C. (c) $1.46 m$

D. (d) $3.2 m$

Answer: C

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41. Three identical particles with velocities $v_0\hat{i}$, $-3v_0\hat{j}$ and $5v_0\hat{k}$ collide successively with each other in such a way that they form a single particle. The velocity vector of resultant particle is

A. (a) $\frac{v_0}{3}\left(\hat{i}+\hat{j}+\hat{k}\right)$

B. (b) $\frac{v_0}{3}\left(\hat{i}-\hat{j}+\hat{k}\right)$

C. (c) $\frac{v_0}{3}\left(\hat{i}-3\hat{j}+\hat{k}\right)$

D. (d) $\frac{v_0}{3}\left(\hat{i}-3\hat{j}+5\hat{k}\right)$

Answer: D

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42. A mortar fires a shell of mass M which explodes into two pieces of mass $\frac{M}{5}$ and $\frac{4M}{5}$ at the top of the trajectory. The smaller mass falls very close to the mortar. In the same time bigger piece lands a distance D from the mortar. The shell would have fallen at a distance R from the mortar if there was no explosion. The value of D is (neglect air resistance)

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

B. $\frac{4R}{3}$

C. $\frac{5R}{4}$

D. None of these

Answer: C

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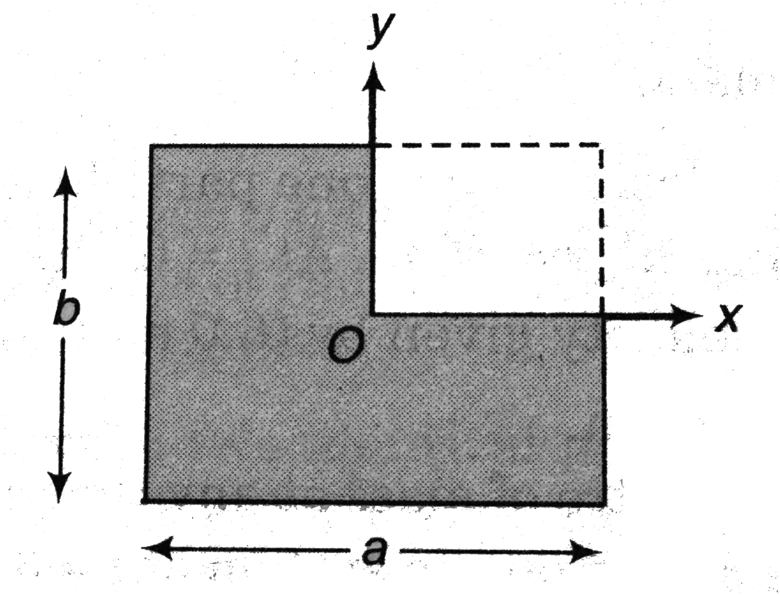
Level 1 Subjective

1. Consider a rectangular plate of dimensions $a \times b$. If this plate is considered to be made up of four rectangles of dimensions $\frac{a}{2} \times \frac{b}{2}$ and we now remove one out of four rectangles. Find the position where the centre of mass of the remaining system will lie?



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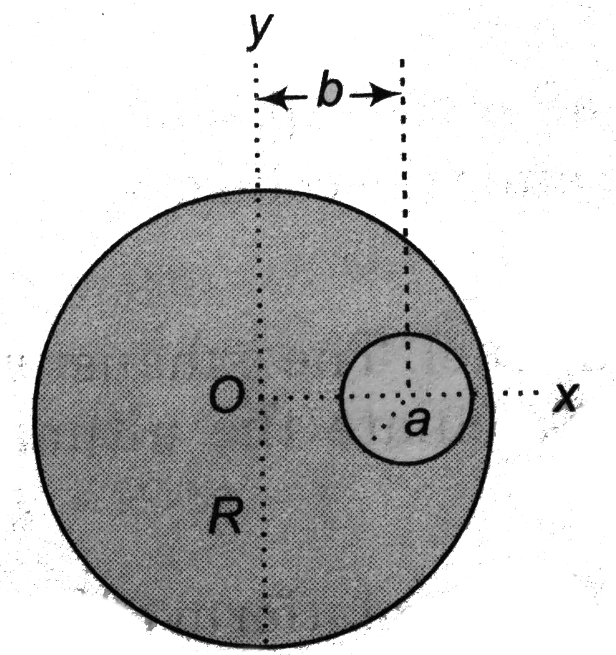
2. The uniform solid sphere shown in the figure has a spherical hole in it. Find the position of its centre of mass.



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3. A gun fires a bullet. The barrel of the gun is inclined at an angle of 45° with horizontal.

When the bullet leaves the barrel it will be travelling at an angle greater than 45° with the horizontal. Is this statement true or false?

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4. Two blocks A and B of masses m_A and m_B are connected together by means of a spring and are resting on a horizontal frictionless table. The blocks are then pulled apart so as to stretch the spring and then released. Show that the kinetic energies of the blocks are, at any instant inversely proportional to their masses.

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5. Show that in a head on elastic collision between two particles, the transference of energy is maximum when their mass ratio is unity.

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6. A particle moving with kinetic energy K makes a head on elastic collision with an identical particle at rest. Find the maximum elastic potential energy of the system during collision.

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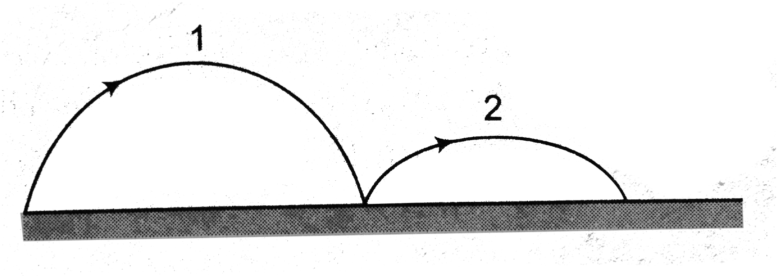
7. A ball is projected from the ground at some angle with horizontal. Coefficient of restitution between the ball and the ground is

e. Let a, b and c be the ratio of times of flight, horizontal range and maximum height in two successive paths. Find a, b and c in terms of e.



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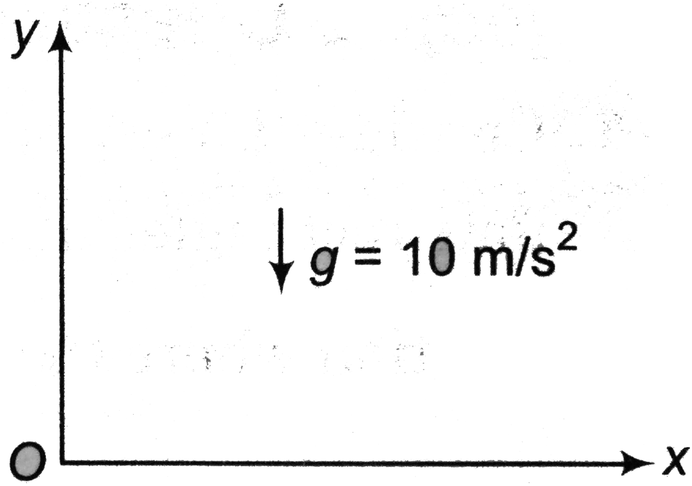
8. $x - y$ is the vertical plane as shown in figure. A particle of mass $1kg$ is at $(10m, 20m)$ at time $t = 0$. It is released from rest. Another particles of mass $2kg$ is at $(20m, 40m)$ at the same instant. It is projected with velocity $\left(10\hat{i} + 10\hat{j}\right)m/s$. After $1s$. Find



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9. A system consists of two particles. At $t = 0$, one particle is at the origin, the other, which has a mass of $0.60kg$, is on the y-axis at $y = 80m$. At $t = 0$, the centre of mass of the system is on the $y - a\xi s$ at $y = 24m$ and has a velocity given by $(6.0m / s^3)t^2\hat{j}$.

(a) Find the total mass of the system.

(b) Find the acceleration of the centre of mass at any time t.

(c) Find the next external force acting on the system at $t = 3.0s$.

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10. A particle of mass $2kg$ moving with a velocity $5\hat{i} m/s$ collides head-on with another particle of mass $3kg$ moving with a velocity $-2\hat{i} m/s$. After the collision the first particle has speed of $1.6 m/s$ in negative x-direction, Find

(a) velocity of the centre of mass after the collision,

(b) velocity of the second particle after the collision.

(c) coefficient of restitution.

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11. A rocket of mass $40kg$ has $160kg$ fuel. The exhaust velocity of the fuel is $2.0km/s$. The rate of consumption of fuel is $4kg/s$. Calculate the ultimate vertical speed gained by the rocket. $(g = 10m/s^2)$

A. 2km/s

B. 2.82km/s

C. 1km/s

D. 10km/s

Answer: B

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12. A boy of mass $60kg$ is standing over a platform of mass $40kg$ placed over a smooth horizontal surface. He throws a stone of mass $1kg$ with velocity $v = 10m/s$ at an angle of 45° with respect to the ground. Find the displacement of the platform (with boy) on the horizontal surface when the stone lands on the ground. Take $g = 10m/s^2$.

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13. A man of mass m climbs to a rope ladder suspended below a balloon of mass M. The balloon is stationary with respect to the ground.

(a) If the man begins to climb the ladder at speed v (with respect to the ladder), in what direction and with what speed (with respect to the ground) will the balloon move?

(b) What is the state of the motion after the man stops climbing?

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14. Find the mass of the rocket as a function of time, if it moves with a constant acceleration a, in absence of external forces. The gas escapes with a constant velocity u relative to the rocket and its mass initially was m_0.

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15. A particle of mass $2m$ is projected at an angle of 45° with horizontal with a velocity of $20\sqrt{2}m/s$. After $1s$ explosion takes place and the particle is broken into two equal pieces. As a result of explosion one part comes to rest. Find the maximum height attained by the other part. Take $g = 10m/s^2$.

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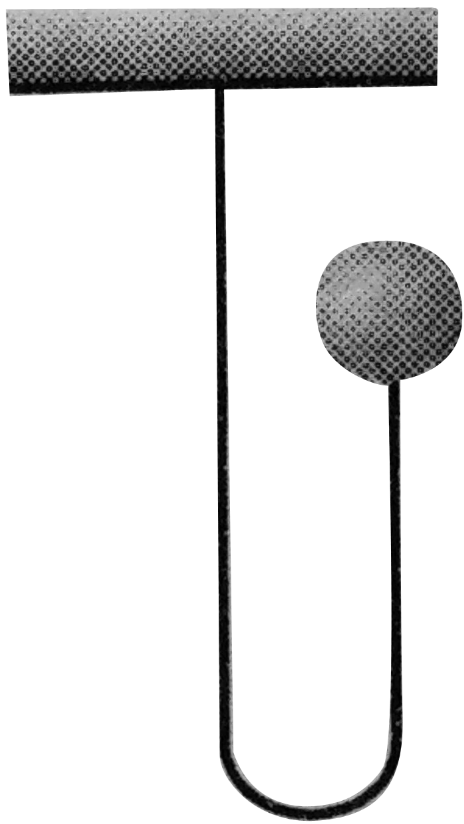
16. A ball of mass $1kg$ is attached to an inextensible string. The ball is released from the position shown in figure. Find the impulse imparted by the string to the ball immediately after the string becomes taut. (Take

$g = 10m / s^2$)



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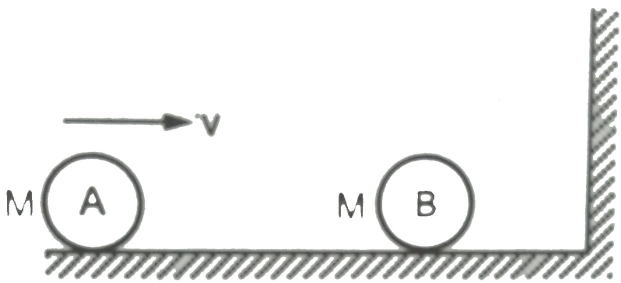
17. The two balls shwon in figure are indentical the first moving at a speed v towards right and the second staying at rest. The wall at the extreme right is fixed. Assume all collisions to be elastic. Show that the speeds of the balls remain unchanged after all the collisions have taken place.



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18. A particle of mass 100 g moving at an initial speed u collides with another particle of same mass kept initially at rest. If the total kinetic energy becomes 0.2 J after the collision what could be minimum and the maximum value of u.

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19. A particle of mass m moving with a speed v hits elastically another staionary particle of mass $2m$ on a smooth horizontal circular tube of radius r. Find the time when the next collision will take place?

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20. In a one-dimensional collision between two identical particles. A and B, B is stationary and A has momentum p before impact. During impact, B gives an impulse J to A. Find the coefficient of restitution between A and B?

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21. Two billiard balls of same size and mass are in contact on a billiard table. A third ball of same mass and size strikes them symmetrically and remains at rest after the impact. Find the coefficient of restitution between the balls?

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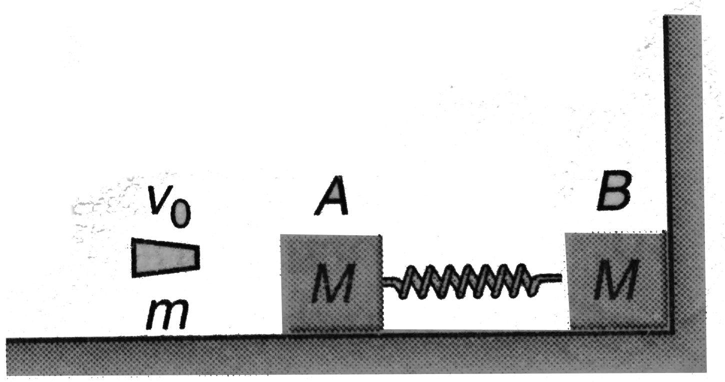
22. Two identical blocks each of mass $M = 9kg$ are placed on a rough horizontal surface of frictional coefficient $\mu = 0.1$. The two blocks are joined by a light spring and block B is in contact with a vertical fixed wall as shown in figure. A bullet of mass $m = 1kg$ and $v_0 = 10m/s$ hits block A and gets embedded in it. Find the maximum compression of spring. (Spring constant $= 240N/m, g = 10m/s^2$)



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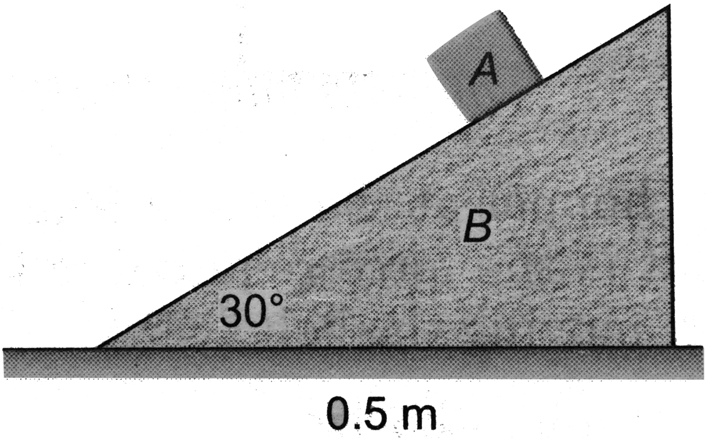
23. Block A has a mass of $5kg$ and is placed on top of a smooth triangular block, B having a mass of $30kg$. If the system is released from rest, determine the distance, B moves when A reaches the bottom. Neglect the size of block A.



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24. A trolley was moving horizontally on a smooth ground with velocity v with respect to the earth. Suddenly a man starts running from rear end of the trolley with a velocity $(3/2)v$ with respect to the trolley. After reaching the other end, the man turns back and continues running with a velocity $(3/2)v$ with respect to trolley in opposite direction. If the length of the trolley is L, find the displacement of the man with respect to earth when he reaches the starting point on the trolley. Mass of the trolley is equal to the mass of the man.

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25. A $4.00g$ bullet travelling horizontally with a velocity of magnitude $500m/s$ is fired into a wooden block with a mass of $1.00kg$, initially at rest on a level surface. The bullet passes through the block and emerges with speed $100m/s$. The block slides a distance of $0.30m$ along the surface from its initial position.

(a) What is the coefficient of kinetic friction between block and surface?

(b) What is the decrease in kinetic energy of the bullet?

(c) What is the kinetic energy of the block at the instant after the bullet has passed through it? Neglect friction during collision of bullet with the block.

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26. A wagon of mass M can move without friction along horizontal rails. A simple pendulum consisting of a sphere of mass m is suspended from the ceiling of the wagon by a string of length l. At the initial moment the wagon and the pendulum are at rest and the string is deflected through an angle α from the vertical. Find the velocity of the wagon when the pendulum passes through its mean position.

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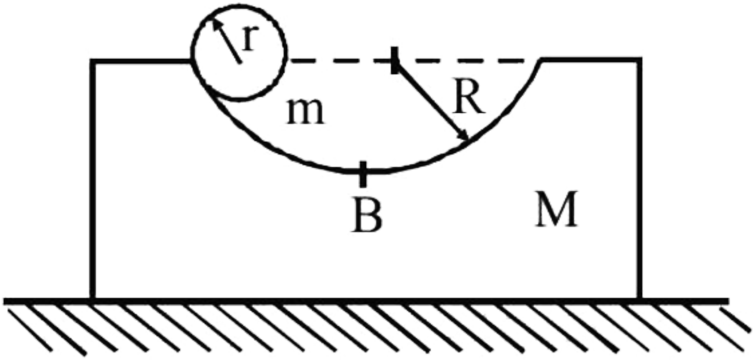
27. A block of mass M with a semicircualr of radius R, rests on a horizontal frictionless surface. A uniform cylinder of radius r and mass m is released from rest the top point A The cylinder slips on the semicircular frictionless track. How far has the block moved when the cylinder reaches the bottom (point B) of the track ? How fast is the block moving when the cylinder reaches the bottom of the track?



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28. A ball of mass 50 g moving at a speed of 2.0 m/s strikes a plane surface at an angle of incidence 45^0. The ball is reflected by the plane at an equal angle of reflection with the same speed. Calculate (a). the magnitude of the change in momentum of the ball (b). the change in the magnitude of the mometum of the ball.

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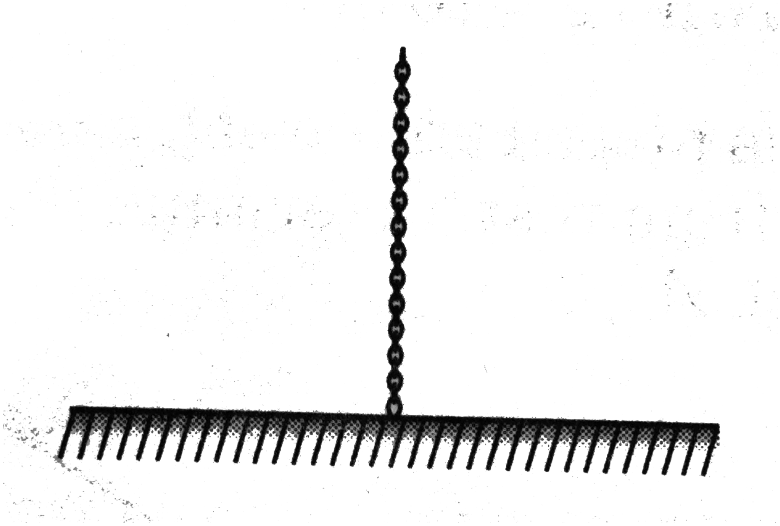
29. A uniform rope of mass m per unit length, hangs vertically from a support so that the lower end just touches the table top shown in figure. If it is released, show that at the time a length y of the rope has fallen, the force on the table is equivalent to the weight of the length $3y$ of the rope.



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30. Sand drops from a stationary hopper at the rate of $5kg/s$ on to a conveyor belt moving with a constant speed of $2m/s$. What is the force required to keep the belt moving and what is the power delivered by the motor, moving the belt?

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31. A $3.0kg$ block slides on a frictionless horizontal surface, first moving to the left at $50m/s$. It collides with a spring as it moves left, compresses the spring and is brought to rest momentarily. The body continues to be accelerated to the right by the force of compressed spring. Finally, the body moves to the right at $40m/s$. The block remains in contact with the spring for $0.020s$. What were the magnitude and direction of the impulse of the spring on the block? What was the spring's average force on the block?

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32. Block A has a mass $3kg$ and is sliding on a rough horizontal surface with a velocity $u_A = 2m/s$ when it makes a direct collision with block B, which has a mass of $2kg$ and is originally at rest. The collision is perfectly elastic. Determine the velocity of each block just after collision and the distance between the blocks when they stop sliding. The coefficient of kinetic friction between the blocks and the plane is $\mu_k = 0.3$ (Take $g = 10m / s^2$)

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Level 1 Subjective Questions

1. A bullet of mass $0.25kg$ is fired with velocity $302m/s$ into a block of wood of mass $m_1 = 37.5kg$. It gets embedded into it. The block m_1 is resting on a long block m_2 and the horizontal surface on which it is placed is smooth. The coefficient of friction between m_1 and m_2 is 0.5. Find the displacement of m_1 on m_2 and the common velocity of m_1 and m_2. Mass $m_2 = 1.25kg$.

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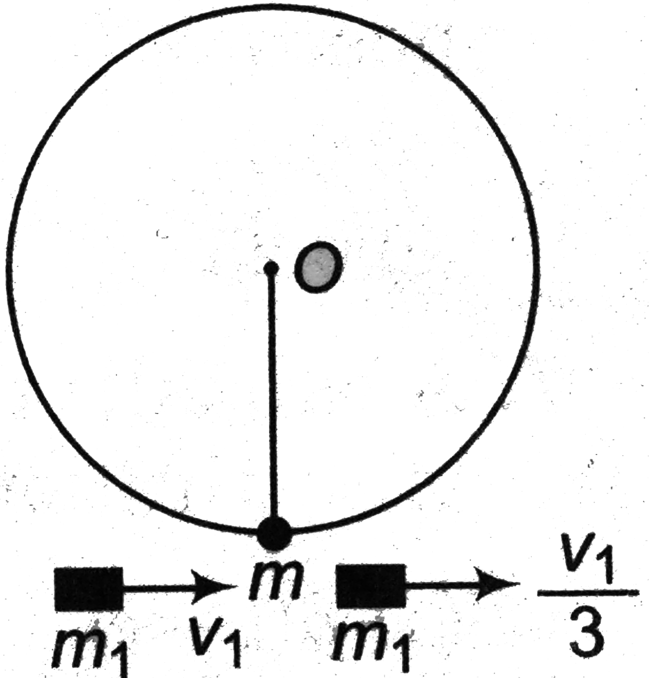
Level 2 Single Correct

1. A pendulum comsists of a wooden bob of mass m and length l. A bullet of mass m_1 is fired towards the pendulum with a speed v_1 and it emerges from the bob with speed $\frac{v_1}{3}$. The bob just completes motion along a vertical circle. Then v_1 is



A. (a) $\dfrac{m}{m_1}\sqrt{5gl}$

B. (b) $\dfrac{3m}{2m_1}\sqrt{5gl}$

C. (c) $\dfrac{2}{3}\left(\dfrac{m}{m_1}\right)\sqrt{5gl}$

D. (d) $\left(\frac{m_1}{m}\right)\sqrt{gl}$

Answer: B

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2. A bob of mass m attached with a string of length l tied to a point on ceiling is released from a position when its string is horizontal. At the bottom most point of its motion, an identical mass m gently stuck to it. Find the maximum angle from the vertical to which it rotates.

A. (a) $\cos^{-1}\left(\frac{2}{3}\right)$

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

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

D. (d) 60°

Answer: B

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3. A train of mass M is moving on a circular track of radius R with constant speed v. The length of the train is half of the perimeter of the track. The linear momentum of the train will be

A. (a) zero

B. (b) $\frac{2Mv}{\pi}$

C. (c) MvR

D. (d) Mv

Answer: B

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4. Two blocks A and B of mass m and $2m$ are connected together by a light spring of stiffness k. The system is lying on a smooth horizontal surface with block A in contact with a fixed vertical wall as shown in the figure. The block B is pressed towards the wall by a distance x_0 and then released. There is not friction anywhere. If spring takes time Δt to aquire its natural length then average force on the block A by the wall is

A. (a) zero

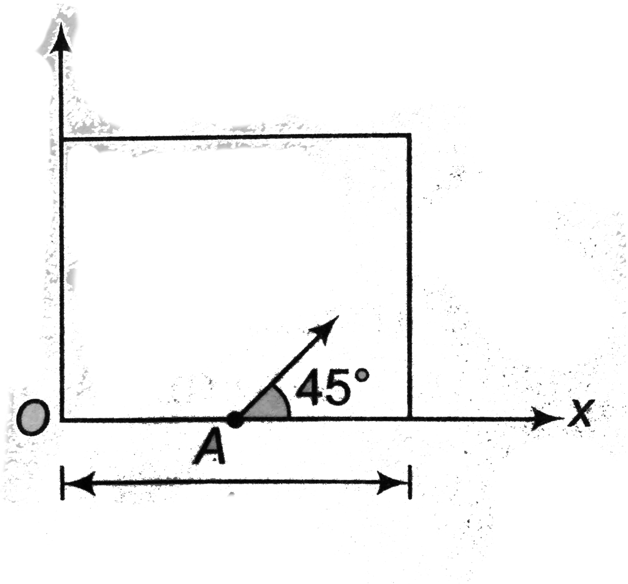
B. (b) $\frac{\sqrt{2mk}}{\Delta t} x_0$

C. (c) $\frac{\sqrt{mk}}{\Delta t} x_0$

D. (d) $\frac{\sqrt{3mk}}{\Delta t} x_0$

Answer: B

5. A striker is shot from a square carom board from a point A exactly at midpoint of one of the walls with a speed of $2ms^{-1}$ at an angle of 45° with the x-axis as shown in the figure. The collisions of the striker with the walls of the fixed carom are perfectly elastic. The coefficient of kinetic friction between the striker and board is 0.2. The coordinate of the striker when it stops (taking point O to be origin) is (in SI units)



A. (a) $\frac{1}{2\sqrt{2}}, \frac{1}{\sqrt{2}}$

B. (b) $0, \frac{1}{2\sqrt{2}}$

C. (c) $\frac{1}{2\sqrt{2}}, 0$

D. (d) $\frac{1}{\sqrt{2}}, \frac{1}{2\sqrt{2}}$

Answer: A

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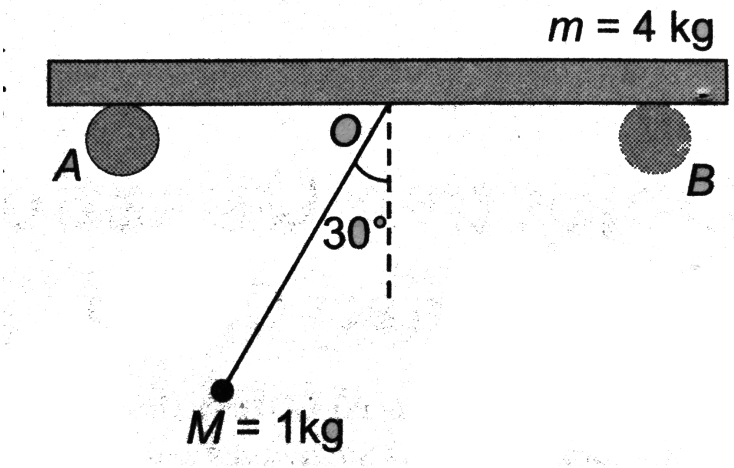
6. A ball of mass $1kg$ is suspended by an inextensible string $1m$ long attached to a point O of a smooth horizontal bar resting on fixed smooth supports A and B. The ball is released from rest from the position when the string makes an angle 30° with the vertical. The mass of the bar is $4kg$. The displacement of bar when ball reaches the other extreme position (in m) is



A. (a) 0.4

B. (b) 0.2

C. (c) 0.25

D. (d) 0.5

Answer: B

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7. A ball falls vertically onto a floor with momentum p and then bounces repeatedly. If coefficient of restitution is e, then the total momentum imparted by the ball to the floor is

A. (a) $p(1+e)$

B. (b) $\dfrac{p}{1-e}$

C. (c) $p\left(\dfrac{1-e}{1+e}\right)$

D. (d) $p\left(\dfrac{1+e}{1-e}\right)$

Answer: D

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8. A bullet of mass mm penetrates a thickness h of a fixed plate of mass M. If the plate was free to move, then the thickness penetrated will be

A. (a) $\frac{Mh}{M+m}$

B. (b) $\frac{2Mh}{M+m}$

C. (c) $\frac{mh}{2(M+m)}$

D. (d) $\dfrac{Mh}{2(M+m)}$

Answer: A

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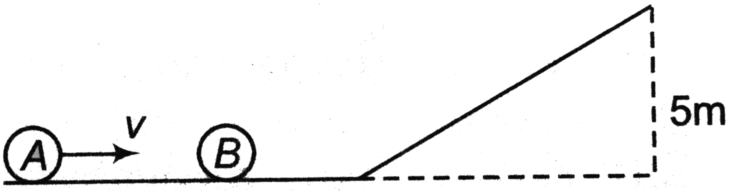
9. Two identical balls of equal masses A and B, are lying on a smooth surface as shown in the figure. Ball A hits the ball B (which is at rest) with a velocity $v = 16ms^{-1}$. What should be the minimum value of coefficient of restitution e between A and B so that B just reaches the highest point of inclined plane?

$(g = 10ms^{-2})$



(c) $\frac{1}{2}$

A. (a) $\frac{2}{3}$

B. (b) $\frac{1}{4}$

C. (c) $\frac{1}{2}$

D. (d) $\frac{1}{3}$

Answer: B

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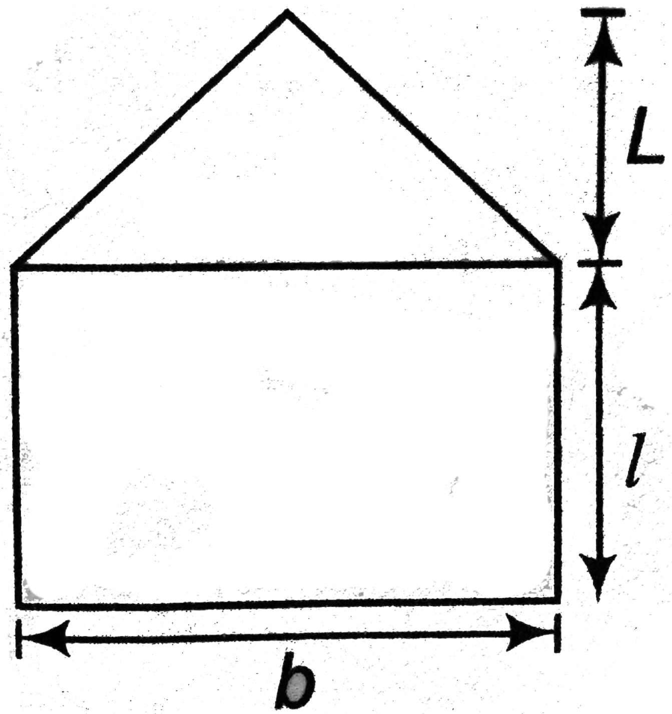
10. The figure shows a metallic plate of uniform thickness and density. The value of l in terms of L so that the centre of mass of the system lies at the interface of the triangular

and rectangular portion is



A. $l = \frac{L}{3}$

B. $l = \frac{L}{2}$

C. $l = \frac{L}{\sqrt{3}}$

D. $l = \sqrt{\frac{2}{3}}L$

Answer: C

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11. Particle A makes a head on elastic collision with another stationary particle B. They fly apart in opposite directions with equal speeds. The mass ratio will be

A. $\frac{1}{3}$

B. $\frac{1}{2}$

C. $\frac{1}{4}$

D. $\frac{2}{3}$

Answer: A

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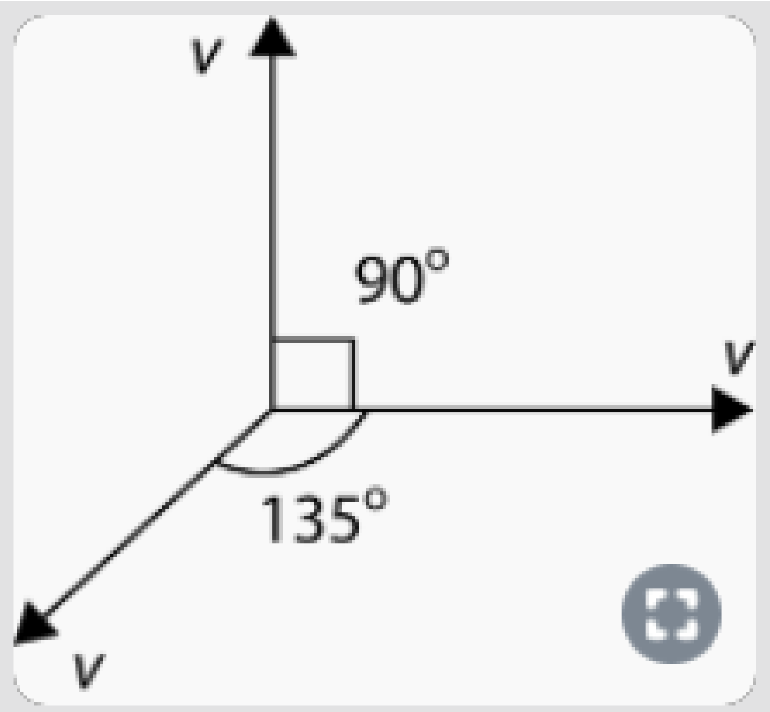
12. A particle of mass $4m$ which is at rest explodes into four equal fragments. All four fragments scattered in the same horizontal plane. Three fragments are found to move with velocity v as shown in the figure. The total energy released in the process is



A. (a) $mv^2(3-\sqrt{2})$

B. (b) $\frac{1}{2}mv^2(3-\sqrt{2})$

C. (c) $2mv^2$

D. (d) $\frac{1}{2}mv^2(1+\sqrt{2})$

Answer: A

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13. A ladder of length L is slipping with its ends against a vertical wall and a horizontal floor. At a certain moment, the speed of the end in contact with the horizontal floor is v and the ladder makes an angle $\theta = 30^\circ$ with horizontal. Then, the speed of the ladder's centre of mass must be

A. (a) $\frac{\sqrt{3}}{2}v$

B. (b) $\frac{v}{2}$

C. (c) v

D. (d) $2v$

Answer: C

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14. A body of mass $2g$, moving along the positive x-axis in gravity free space with velocity $20cms^{-1}$ explodes at $x = 1m$, $t = 0$ into two pieces of masses $2/3g$ and $\frac{4}{3}g$. After $5s$, the lighter piece is at the point $(3m, 2m, -4m)$. Then the position of the heavier piece at this moment, in metres is

A. (a) $(1.5, -1, -2)$

B. (b) $(1.5, -2, -2)$

C. (c) $(1.5, -1, -1)$

D. (d) None of these

Answer: D

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15. A body of mass m is dropped from a height of h. Simultaneously another body of mass $2m$ is thrown up vertically with such a velocity v that they collide at height $\frac{h}{2}$. If the collision is perfectly inelastic, the velocity of combined mass at the time of collision with the ground will be

A. (a) $\sqrt{\frac{5gh}{4}}$

B. (b) $\sqrt{gh}$

C. (c) $\sqrt{\frac{gh}{4}}$

D. (d) None of these

Answer: D

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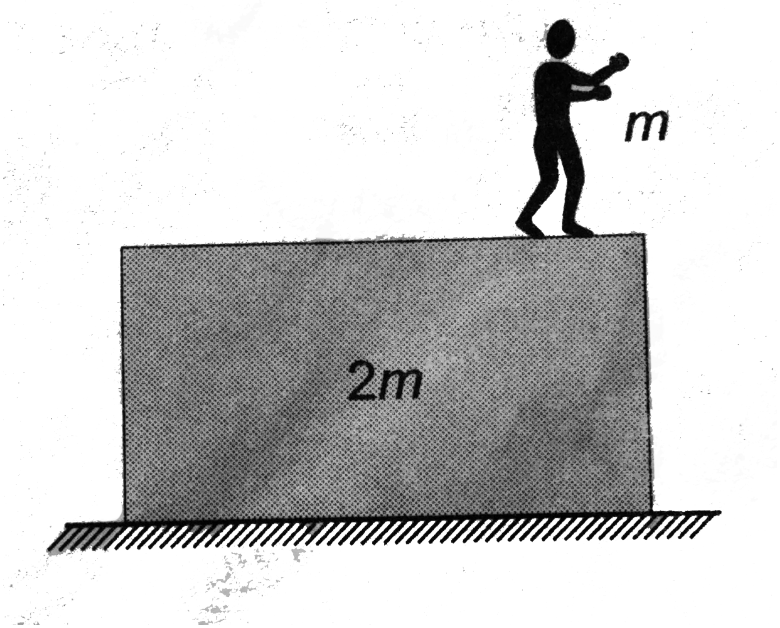
16. A man is standing on a cart of mass double the mass of man. Initially cart is at rest. Now, man jumps horizontally with velocity u relative to cart. Then work done by man during the process of jumping will be



A. $\frac{\mu^2}{2}$

B. $\frac{3\mu^2}{4}$

C. μ^2

D. None of these

Answer: D

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17. Two balls of equal mass are projected upwards simultaneously, one from the ground with initial velocity $50ms^{-1}$ and the other from a $40m$ tower with initial velocity of

$30ms^{-1}$. The maximum height attained by their COM will be

A. $80m$

B. $60m$

C. $100m$

D. $120m$

Answer: C

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18. A particle of mass m and momentum p moves on a smooth horizontal table and collides directly and elastically with a similar particle (of mass m) having momentum $-2p$. The loss $(-)$ or gain $(+)$ in the kinetic energy of the first particle in the collision is

A. (a) $+\frac{p^2}{2m}$

B. (b) $-\frac{p^2}{4m}$

C. (c) $+\frac{3p^2}{2m}$

D. (d) zero

Answer: C

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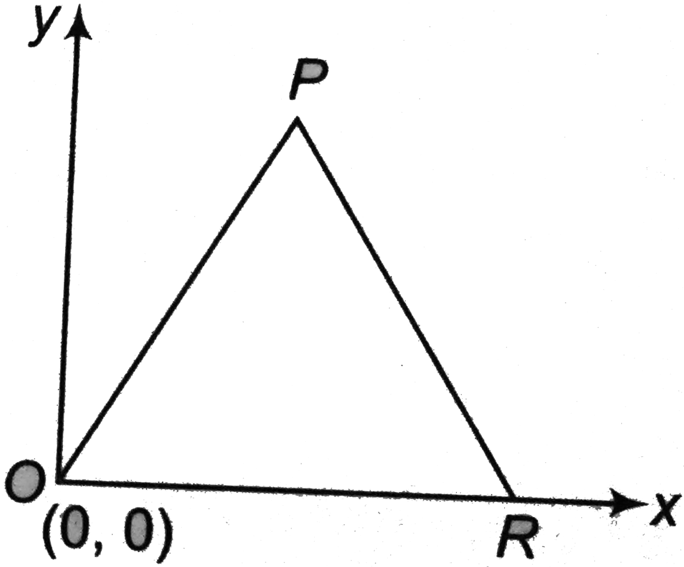
19. An equilateral triangular plate of mass $4m$ of side a is kept as shown. Consider two cases: (i) a point mass $4m$ is placed at the vertex P of the plate (ii) a point mass m is placed at the vertex R of the plate. In both cases the x-coordinate of centre of mass remains the same. Then x coordinate of centre of mass of the plate is



A. (a) $\frac{a}{3}$

B. (b) $\frac{a}{6}$

C. (c) $\frac{6a}{7}$

D. (d) $\frac{2a}{3}$

Answer: B

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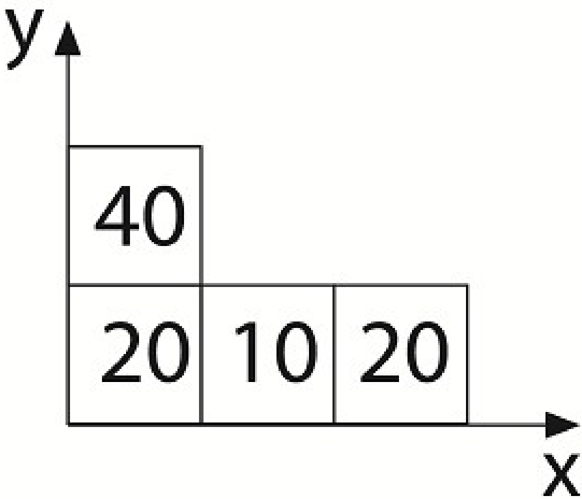
20. Four cubes of side a each of mass $40g$, $20g$, $10g$ and $20g$ are arranged in XY plane as shown in the figure. The coordinates of COM of the combination with respect to point O is



A. $\frac{19a}{18}, \frac{17a}{18}$

B. $\frac{17a}{18}, \frac{11a}{18}$

C. $\frac{17a}{18}, \frac{13a}{18}$

D. $\frac{13a}{18}, \frac{17a}{18}$

Answer: A

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21. A particle of mass m_0, travelling at speed v_0. Strikes a stationary particle of mass $2m_0$. As a result of the particle of mass m_0 is deflected through 45° and has a final speed of $\frac{v_0}{\sqrt{2}}$. Then the speed of the particle of mass $2m_0$ after this collision is

A. (a) $\frac{v_0}{2}$

B. (b) $\frac{v_0}{2\sqrt{2}}$

C. (c) $\sqrt{2}v_0$

D. (d) $\frac{v_0}{\sqrt{2}}$

Answer: B

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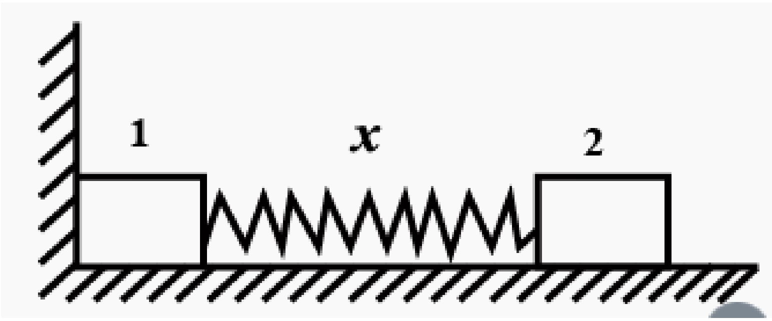
22. Two bars of masses m_1 and m_2 connected by a weightless spring of stiffness k, rest on a smooth horizontal plane. Bar 2 is shifted by a small distance x_0 to the left and released. The veloicyt of the centre of mass of the system when bar 1 breaks off the wall is



A. (a) $x_0 \sqrt{\dfrac{k m_2}{m_1 + m_2}}$

B. (b) $\dfrac{x_0}{m_1 + m_2} \sqrt{k m_2}$

C. (c) $x_0 k \dfrac{m_1 + m_2}{m_2}$

D. (d) $x_0 \dfrac{\sqrt{k m_1}}{(m_1 + m_2)}$

Answer: B

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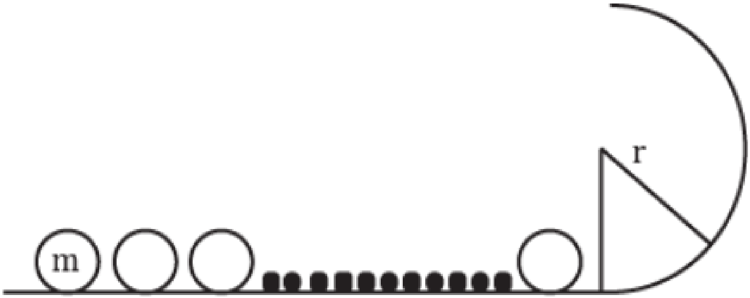
23. n elastic balls are placed at rest on a smooth horizontal plane which is circular at the ends with radius r as shown in the figure. The masses of the balls are $m, \frac{m}{2}, \frac{m}{2^2}, \ldots\ldots\ldots\ldots\ldots \frac{m}{2^{n-1}}$ respectively. What is the minimum velocity which should be imparted to the first ball of mass m such that n^th ball completes the vertical circle



A. $\left(\frac{3}{4}\right)^{n-1}\sqrt{5gr}$

B. $\left(\frac{4}{3}\right)^{n-1}\sqrt{5gr}$

C. $\left(\frac{3}{2}\right)^{n-1}\sqrt{5gr}$

D. $\left(\frac{2}{3}\right)^{n-1}\sqrt{5gr}$

Answer: A

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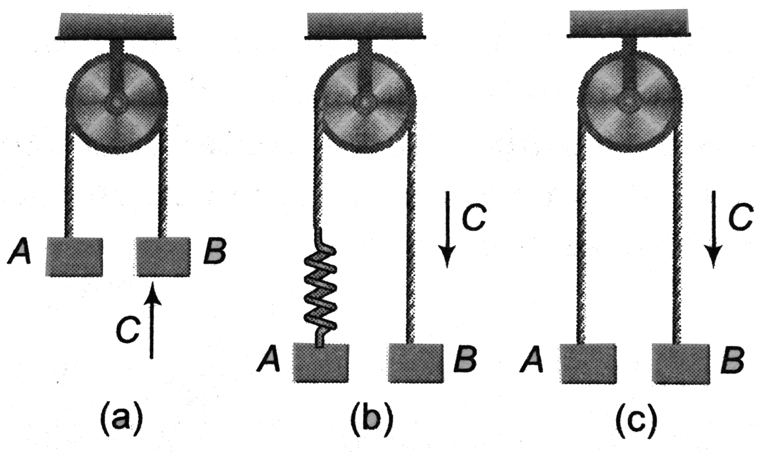
Level 2 Single Correct Option

1. In figures (a), (b) and (c) shown, the objects A, B and C are of same mass. String, spring and pulley are massless. C strikes B with velocity u in each case and sticks it. The ratio of velocity of B in case (a) to (b) to (c) is



A. (a) $1:1:1$

B. (b) $3:3:2$

C. (c) $3:2:2:$

D. (d) $1:2:3$

Answer: B

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Level 2 More Than One Correct

1. A particle of mass m, moving with velocity v collides a stationary particle of mass $2m$. As a result of collision, the particle of mass m deviates by 45° and has final speed of $\frac{v}{2}$. For this situation mark out the correct statement (s).

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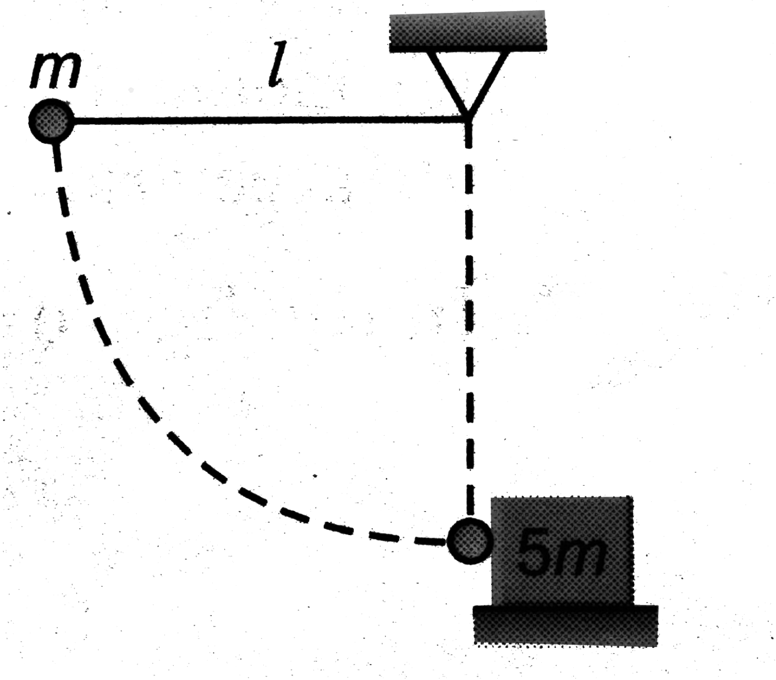
2. A pendulum bob of mass m connected to the end of material string of length l is released from rest from horizontal position as shown in the figure. At the lowest point the bob makes an elastic collision with a stationary block of mass $5m$, which is kept on a frictionless surface. Choose out the correct statement(s) for the instant just after the impact.



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3. A particle of mass m strikes a horizontal smooth floor with velocity u making an angle θ

with the floor and rebound with velocity v making an angle θ with the floor. The coefficient of restitution between the particle and the floor is e. Then

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4. A particle of mass m moving with a velocity $\left(3\hat{i}+2\hat{j}\right)ms^{-1}$ collides with another body of mass M and finally moves with velocity $\left(-2\hat{i}+\hat{j}\right)ms^{-1}$. Then during the collision

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5. All surfaces shown in figure are smooth. System is released from rest. x and y comonents of acceleration of COM are

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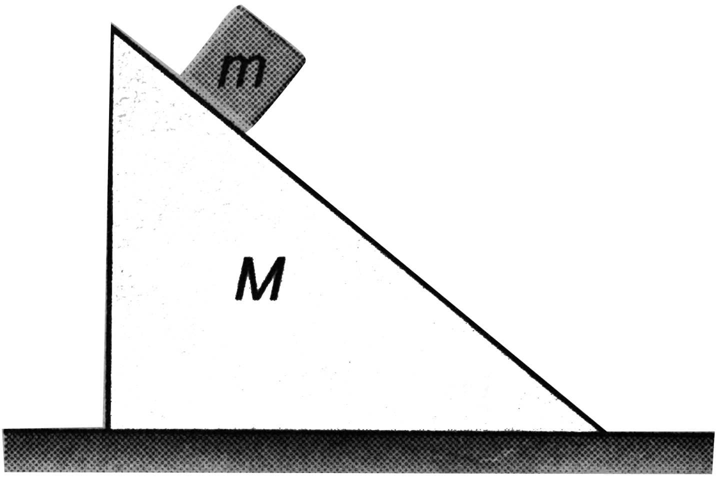
6. A block of mass m is placed at rest on a smooth wedge of mass M placed at rest on a smooth horizontal surface. As the system is released



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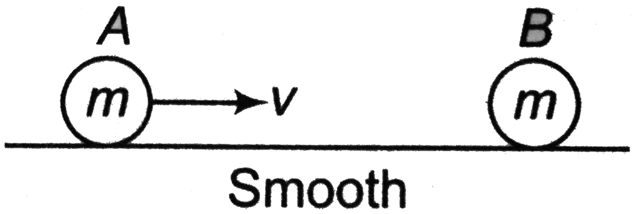
7. In the figure shown, coefficient of restitution between A and B is $e = \frac{1}{2}$, then



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8. In case of rocket propulsion, choose the correct options.

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Level 2 Comprehension Based

1. A block of mass $2kg$ is attached with a spring of spring constant $4000Nm^{-1}$ and the system is kept on smooth horizontal table. The other end of the spring is attached with a wall. Initially spring is stretched by $5cm$ from its natural position and the block is at rest. Now suddenly an impulse of $4kg - ms^{-1}$ is given to the block towards the wall.

Find the velocity of the block when spring acquires its natural length

A. (a) $5ms^{-1}$

B. (b) $3ms^{-1}$

C. (c) $6ms^{-1}$

D. (d) None of these

Answer: B

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2. A block of mass $2kg$ is attached with a spring of spring constant $4000Nm^{-1}$ and the system is kept on smooth horizontal table. The other end of the spring is attached with a wall.

Initially spring is stretched by $5cm$ from its natural position and the block is at rest. Now suddenly an impulse of $4kg - ms^{-1}$ is given to the block towards the wall.

Approximate distance travelled by the block when it comes to rest for a second time (not including the initial one) will be (Take $\sqrt{45} = 6.70$)

A. (a) $30cm$

B. (b) $25cm$

C. (c) $40cm$

D. (d) $20cm$

Answer: B

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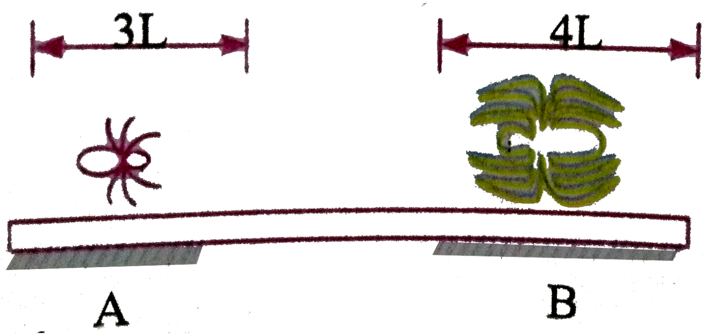
3. A uniform bar of length $12L$ and mass $48m$ is supported horizontally on two smooth tables as shown in the figure. A small moth (an insect) of mass $8m$ is sitting on end A of the rod and a spider (an insect) of mass $16m$ is sitting on the other end B. Both the insects start moving towards each other along the rod with moth moving at speed $2v$ and the spider at half of this speed. They meet at a point P on the rod and the spider eats the moth. After this the spider moves with a velocity $v/2$ relative to the rod towards the end A. The spider takes negligible time in eating the insect. Also, let $v = L/T$, where T is a constant having value $4\,\mathrm{sec}$.



The point P is at

A. (a) the centre of the rod

B. (b) the edge of the table supporting the end B

C. (c) the edge of the table supporting end A

D. (d) None of the above

Answer: B

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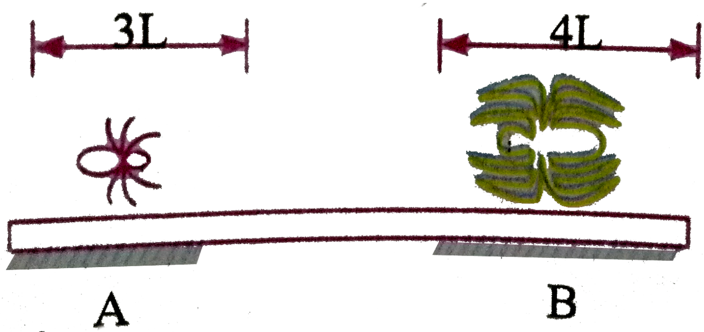
4. A uniform bar of length $12L$ and mass $48m$ is supported horizontally on two smooth tables as shown in the figure. A small moth (an insect) of mass $8m$ is sitting on end A of the rod and a spider (an insect) of mass $16m$ is sitting on the other end B. Both the insects start moving towards each other along the rod with moth moving at speed $2v$ and the spider at half of this speed. They meet at a point P on the rod and the spider eats the moth. After this the spider moves with a velocity $v/2$ relative to the rod towards the end A. The spider takes negligible time in eating the insect. Also, let $v = L/T$, where T is a constant having value $4\,\mathrm{sec}$.



The speed of the bar after the spider eats up the moth and moves towards A is

A. (a) $\frac{v}{2}$

B. (b) v

C. (c) $\frac{v}{6}$

D. (d) $2v$

Answer: C

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Level 2 Comprehension Based Questions

1. A block of mass $2kg$ is attached with a spring of spring constant $4000Nm^{-1}$ and the system is kept on smooth horizontal table. The other end of the spring is attached with a wall.

Initially spring is stretched by $5cm$ from its natural position and the block is at rest. Now suddenly an impulse of $4kg - ms^{-1}$ is given to the block towards the wall.

Approximate distance travelled by the block when it comes to rest for a second time (not including the initial one) will be (Take $\sqrt{45} = 6.70$)

Displacement of the rod by the time the insect meet the moth is

A. (a) $\frac{L}{2}$

B. (b) L

C. (c) $\frac{3L}{4}$

D. (d) zero

Answer: D

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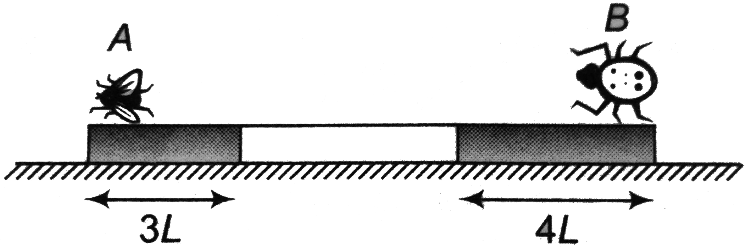
2. A uniform bar of length $12L$ and mass $48m$ is supported horizontally on two fixed smooth tables as shown in figure. A small moth (an insect) of mass $8m$ is sitting on end A of the rod and a spider (an insect) of mass $16m$ is sitting on the other end B. Both the insects moving towards each other along the rod with moth moving at speed $2v$ and the spider at half this speed (absolute). They meet at a point P on the rod and the spider eats the moth. After this the spider moves with a velocity $\frac{v}{2}$ relative to the rod towards the end A. The spider takes negligible time in eating on the other insect. Also, let $v = \frac{L}{T}$ where T is a constant having value $4s$.



After starting from end B of the rod the spider reaches the end A at a time

A. (a) $40s$

B. (b) $30s$

C. (c) $80s$

D. (d) $10s$

Answer: C

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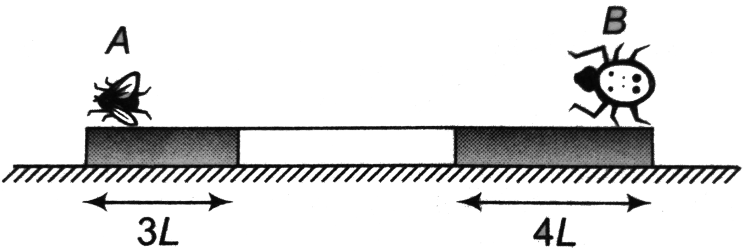
3. A uniform bar of length $12L$ and mass $48m$ is supported horizontally on two fixed smooth tables as shown in figure. A small moth (an insect) of mass $8m$ is sitting on end A of the rod and a spider (an insect) of mass $16m$ is sitting on the other end B. Both the insects moving towards each other along the rod with moth moving at speed $2v$ and the spider at half this speed (absolute). They meet at a point P on the rod and the spider eats the moth. After this the spider moves with a velocity $\frac{v}{2}$ relative to the rod towards the end

A. The spider takes negligible time in eating on the other insect. Also, let $v = \frac{L}{T}$ where T is a constant having value $4s$.



By what distance the centre of mass of the rod shifts during this time?

A. (a) $\frac{8L}{3}$

B. (b) $\frac{4L}{3}$

C. (c) L

D. (d) $\frac{L}{3}$

Answer: A

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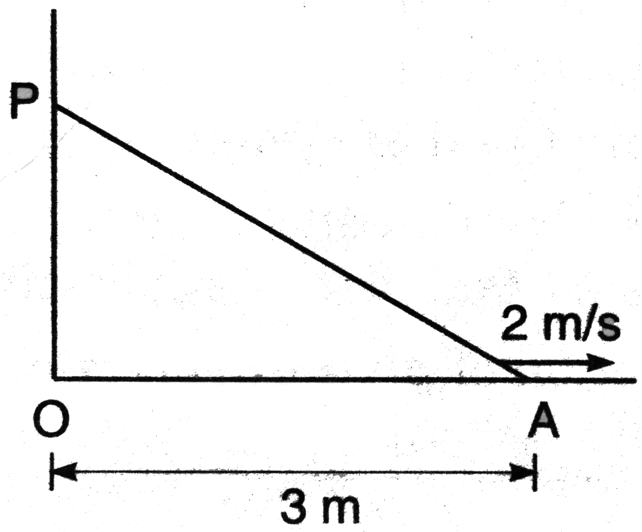
Level 2 Subjective

1. A ladder AP of length $5m$ inclined to a vertical wall is slipping over a horizontal surface with velocity of $2m/s$, when A is at distance $3m$ from ground. What is the velocity of COM at this moment?



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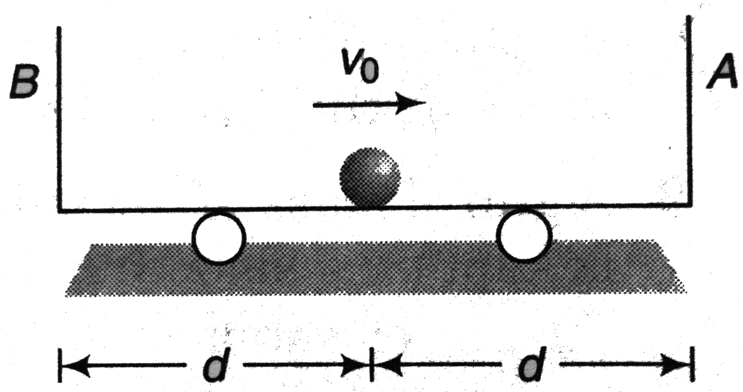
2. A ball of negligible size and mass m is given a velocity v_0 on the centre of the cart which has a mass M and is originally at rest. If the

coefficient of restitution between the ball and walls A and B is e. Determine the velocity of the ball and the cart just after the ball strikes A. Also, determine the total time needed for the ball to strike A, rebound, then strike B, and rebound and then return to the centre of the cart. Neglect friction.



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3. Two point masses m_1 and m_2 are connected by a spring of natural length l_0. The spring is compressed such that the two point masses touch each other and then they are fastened by a string. Then the system is moved with a velocity v_0 along positive x-axis. When the system reached the origin, the string breaks $(t = 0)$. The position of the point mass m_1 is given by $x_1 = v_0 t - A(1 - \cos \omega t)$ where A and ω are constants. Find the position of the second block as a function of time. Also, find the relation between A and l_0.

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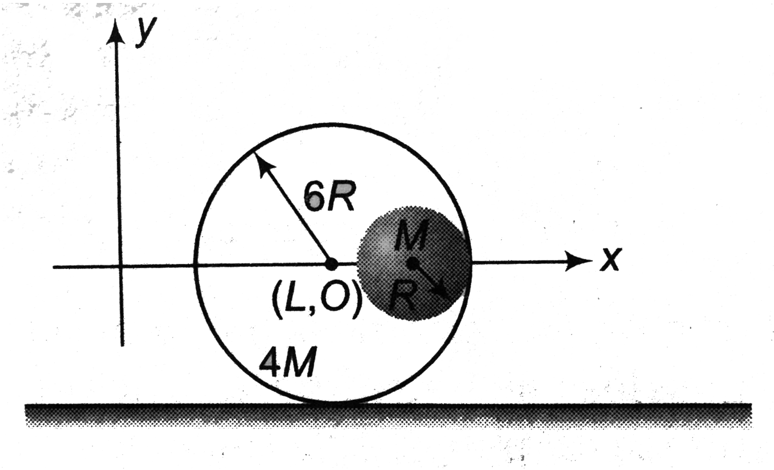
4. A small sphere of radius R is held against the inner surface of larger sphere of radius $6R$ (as shown in figure). The masses of large and small spheres are $4M$ and M respectivley. This arrangement is placed on a horizontal table. There is no friction between any surfaces of contact. The small sphere is now released. Find the coordinates of the centre of the large spheres, when the smaller sphere reaches the other extreme position.



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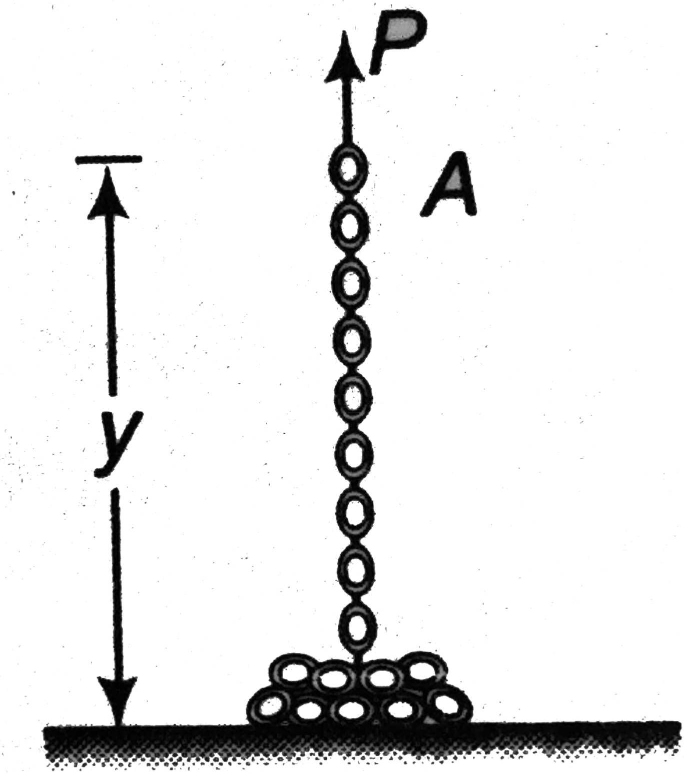
5. A chain of length l and mass m lies in a pile on the floor. If its end A is raised vertically at a constant speed v_0, express in terms of the length y of chain which is off the floor at any given instant.

(a) The magnitude of the force P applied to end A.

(b) Energy lost during the lifting of the chain.



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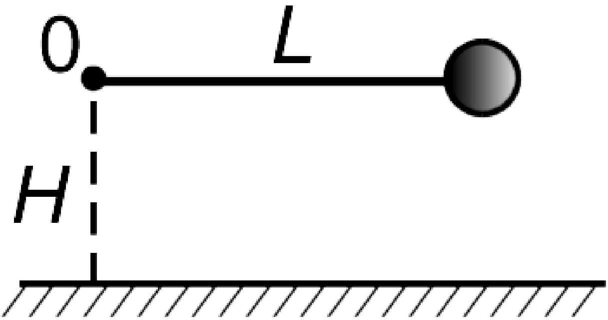
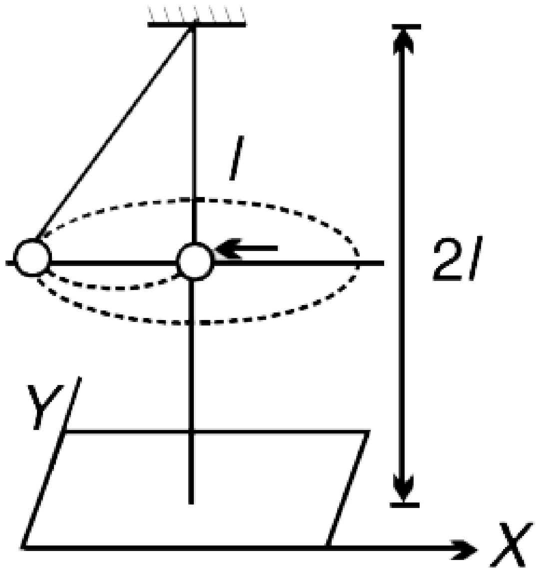
6. (i) O is a fixed peg at a height H above a perfectly inelastic smooth horizontal plane. A light inextensible string of length $L(>H)$ has one end attached to O and the other end is attached to a heavy particle. The particle is held at the level of O with string horizontal and just taut and released from rest. Find the height of the particle above the plane when it comes to rest for the first time after the release.



(ii) The bob of a pendulum has mass m and the length of pendulum is l. It is initially at rest with the string vertical and the point of suspension at a height $2l$ above the floor. A particle P of mass $\frac{m}{2}$ moving horizontally along –ve x-direction with velocity $\sqrt{2gl}$ collides with the bob and comes to rest. The bob swings and when it comes to rest for the first time, another particle Q of mass m moving horizontally along y direction collides with the bob and sticks to it. It is observed that the bob now moves in a horizontal circle.



(a) Find tension in string just before the second collision.

(b) Find the height of the circular path above the floor.

(c) Find the time period of the circular motion.

(d) The string breaks during the circular motion at time $t = 0$. At what time the bob will hit the floor ?

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7. A particle of mass $2m$ is projected at an angle of 45° with horizontal with a velocity of $20\sqrt{2}m/s$. After $1s$ explosion takes place and the particle is broken into two equal pieces. As a result of explosion one part comes to rest.

Find the maximum height attained by the other part. Take $g = 10m/s^2$.

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8. A sphere of mass m, impinges obliquely on a sphere, of mass M, which is at rest. Show that, if $m = eM$, the directions of motion of the sphere after impact are at right angles.

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9. A gun of mass M(including the carriage) fires a shot of mass m. The gun along with the carriage is kept on a smooth horizontal surface. The muzzle speed of the bullet v_r is constant. Find

(a) The elevation of the gun with horizontal at which maximum range of bullet with respect to the ground is obtained.

(b) The maximum range of the bullet.

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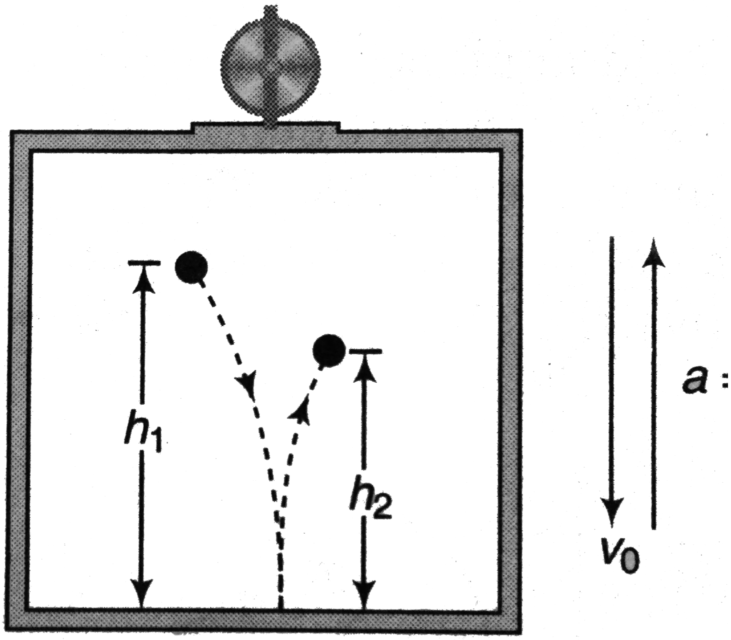
10. A ball is released from rest relative to the elevator at a distance h_1 above the floor. The speed of the elevator at the time of ball release is v_0. Determine the bounce height h_2 relative to elevator of the ball (a) if v_0 is constant and (b) if an upward elevator accleration $a = \dfrac{g}{4}$ begins at the instant the ball is released. The coefficient of restitution for the impact is e.



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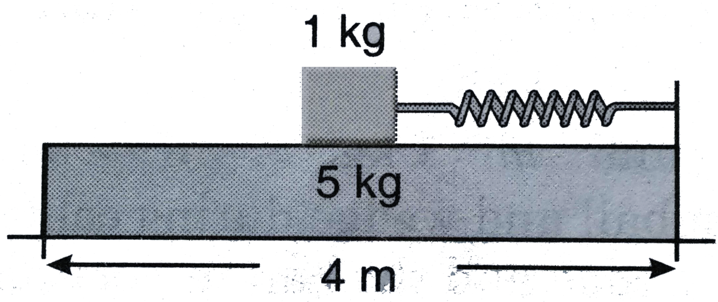
11. A planck of mass $5kg$ is placed on a frictionless horizontal plane. Further a block of mass $1kg$ is placed over the plank. A massless spring of natural length $2m$ is fixed to the plank by its one end. The other end of spring is compressed by the block by half of spring's natural length. They system is now released from the rest. What is the velocity of the plank when block leaves the plank? (The stiffness constant of spring is $100N/m$)



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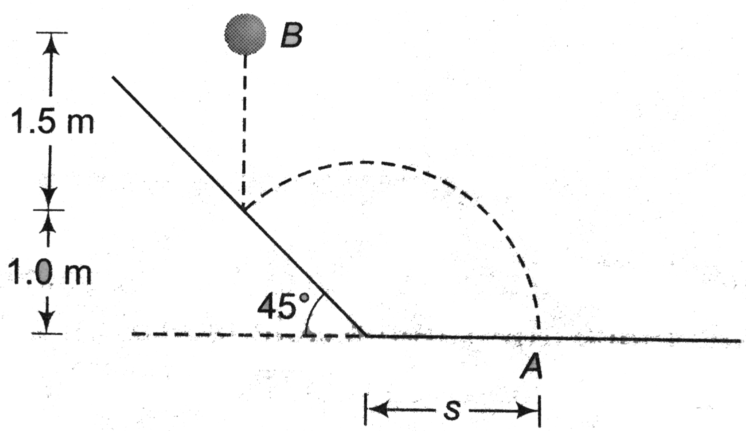
12. To test the manufactured properties of $10N$ steel balls, each ball is released from rest as shown and strikes a 45° inclined surface. If the coefficient of restitution is to be $e = 0.8$, determine the distance s, where the ball must strike the horizontal plane at A. At what speed does the ball stike at A? $(g = 9.8m/s^2)$



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13. Two particles A and B of equal masses lie close together on a horizontal table and are connected by a light inextensible string of length l. A is projected vertically upwards with a velocity $\sqrt{10gl}$. Find the velocity with which it reaches the table again.

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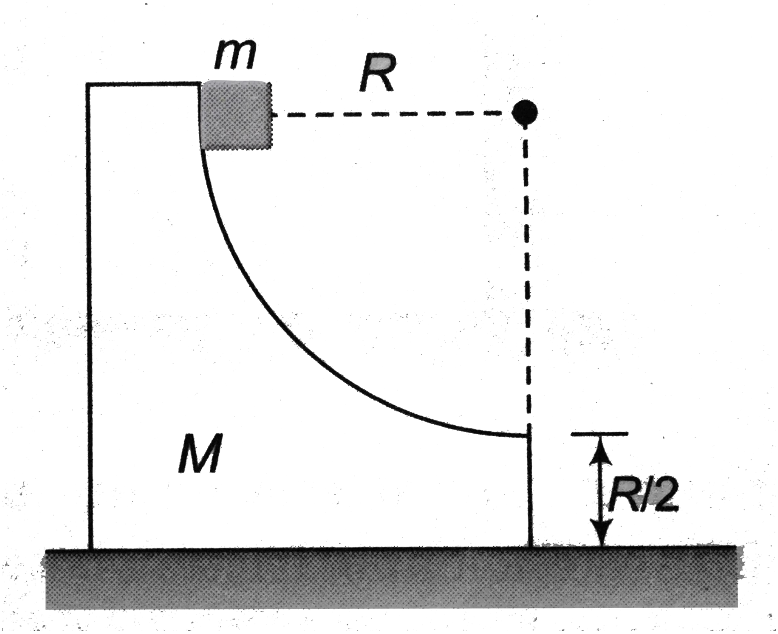
14. A small cube of mass m slides down a circular path of radius R cut into a large block of mass M, as shown in figure. M rests on a table, and both blocks move without friction. The blocks are initially at rest, and m starts from the top of the path. Find the horizontal distance from the bottom of block where cube hits the cable



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15. A thin hoop of mass M and radius r is placed on a horizontal plane. At the initial instant, the hoop is at rest. A small washer of

mass m with zero initial velocity slides from the upper point of the hoop along a smooth groove in the inner surfaces of the hoop. Determine the velocity u of the centre of the hoop at the moment when the washer is at a certain point A of the hoop, whose radius vector forms an angle ϕ with the vertical (figure). The friction between the hoop and the plane should be neglected

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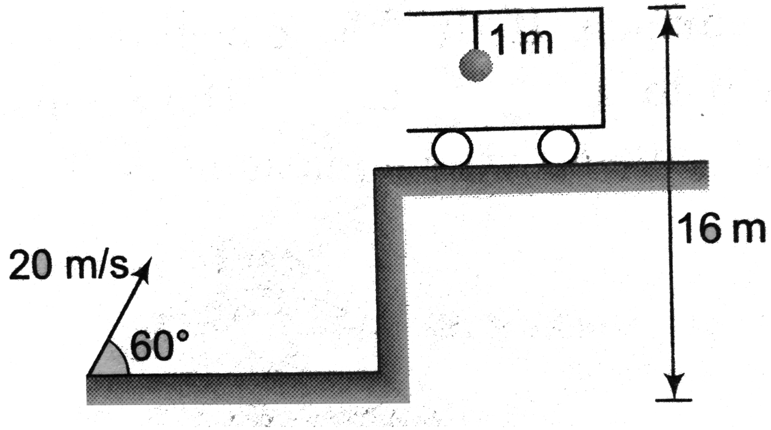
16. A shell of mass $1kg$ is projected with velocity $20m/s$ at an angle 60° with horizontal. It collides inelastically with a ball of mass $1kg$ which is suspended through a thread of length $1m$. The other end of the thread is attached to the ceiling of a trolley of mass $\frac{4}{3}kg$ as shown in figure. Initially the trolley is stationary and it is free to move along horizontal rails wihtout any friction. What is the maximum deflection of the thread with vertical? String does not slack. Take

$g = 10m / s^2$.



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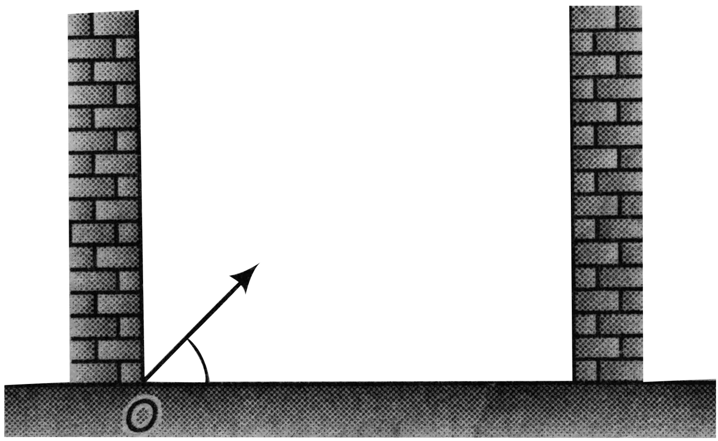
17. A small ball is projected at an angle α between two vertical walls such that in the absence of the wall its range would have been $5d$. Given that all the collisions are perfectly

elastic, find.

(a) maximum height atained by the ball.

(b) total number of collisions with the walls before the ball comes back to the ground, and

(c) point at which the ball finally falls. The walls are supposed to be very tall.



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18. Two large rigid vertical walls A and B are parallel to each other and separated by $10m$. A particle of mass $10g$ is projected with an initial velocity of $20m/s$ at 45° to the horizontal from point P on the ground, such that $AP = 5m$. The plane of motion of the particle is vertical and perpendicular to the walls. Assuming that all the collisions are perfectly elastic, find the maximum height attained by the particle and the total number of collisions suffered by the particle with the walls before it hits ground. Take $g = 10m/s^2$.

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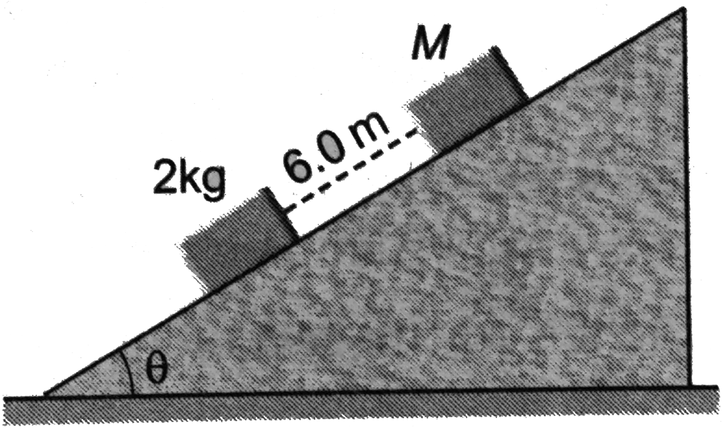
19. Two blocks of masses $2kg$ and M are at rest on an inclined plane and are separated by a distance of $6.0m$ as shown. The coefficient of friction between each block and the inclined plane is 0.25. The $2kg$ block is given a velocity of $10.0m/s$ up the inclined plane. It collides with M, comes back and has a velocity of

$1.0m/s$ when it reaches its initial position. The other block M after the collision moves $0.5m$ up and comes to rest. Calculate the coefficient of restitution between the blocks and the mass of the block M.

[Take $\sin\theta = \tan\theta = 0.05$ and $g = 10m/s^2$]



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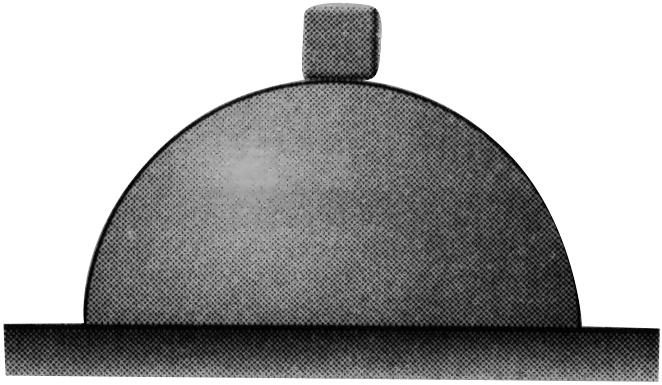
20. A small block of mass m is placed on top of a smooth hemisphere also of mass m which is placed on a smooth horizontal surface. If the block begins to slide down due to a negligible small impulse, show that it will loose contact with the hemisphere when the radial line through vertical makes an angle θ given by the equaition $\cos^3\theta - 6\cos\theta + 4 = 0.$



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21. A ball is projected from a given point with velocity u at some angle with the horizontal and after hitting a vertical wall returns to the same point. Show that the distance of the

point from the wall must be less than $\frac{eu^2}{(1+e)g}$, where e is the coefficient of restitution.

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