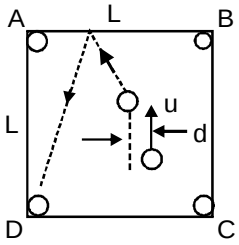
## Exercise - IV — Tough Subjective Problem

**1.** In a game of Carom Board, the Queen (a wooden disc of radius 2 cm and mass 50 gm) is placed at the exact center of the horizontal board. The striker is a smooth plastic disc of radius 3 cm and mass 100 gm. The board is frictionless. Th striker is given an initial velocity 'u' parallel to the sides BC or AD so that is hits the Queen inelastically with same coefficient of restitution = 2/3. The impact parameter for the collision is 'd' (shown in the figure). The Queen rebounds from the edge AB of the board inelastically with same coefficient of restitution = 2/3. and enters the hole D following the dotted path shown. The side of the board is L. Find the value of impact parameter 'd' and the time which the Queen takes to enter hole D after collision with the striker.




**2.** A flexible chain has a length $l$ and mass m. It is lowered on the table top with constant velocity v. Find the force that the chain exerts on the table as a function of time.

**3.** A 24-kg projectile is fired at an angle of 53° above the horizontal with an initial speed of 50 m/s. At the highest point in its trajectory, the projectile explodes into two fragments of equal mass, the first of which falls vertically with zero initial speed.

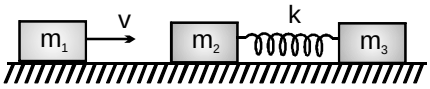
(a) How far from the point of firing does the second fragment strike the ground? (Assume the ground is level.)

(b) How much energy was released during the explosion?

**4.** A particle is projected from point O on level ground towards a smooth vertical wall 50m from O and hits the wall. The initial velocity of the particle is 30m/s at 45° to the horizontal and the coefficient of restitution between the particle and the wall is e. Find the distance from O of the point at which the particle hits the ground again if (a) e = 0, (b) e = 1, (c) e = 1/2

**5.** A massive vertical wall is approaching a man at a speed u. When it is at a distance of 10m, the man throws a ball with speed 10 m/s an at angle of 37° which after completely elastic rebound reaches back directly into his bands. Find the velocity u of the wall.

**6.** Mass $m_1$ hits & sticks with $m_2$ while sliding horizontally with velocity v along the common line of centres of the three equal masses ($m_1 = m_2 = m_3 = m$). Initially masses $m_2$ and $m_3$ are stationary and the spring is unstretched. Find




Frictionless

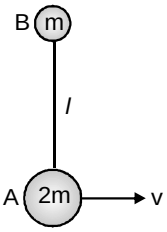
(a) the velocities of $m_1$, $m_2$ and $m_3$ immediately after impact.

(b) the maximum kinetic energy of $m_3$.

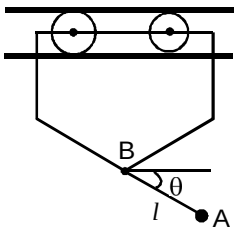
(c) the minimum kinetic energy of $m_2$.

(d) the maximum compression of the spring.

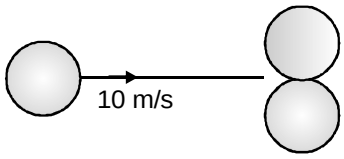
**7.** Two masses A and B connected with an inextensible string of length $l$ lie on a smooth horizontal plane. A is given a velocity of v m/s along the ground perpendicular to line AB as shown in figure. Find the tension in string during their sub sequent motion.




**8.** The simple pendulum A of mass $m_A$ and length $l$ is suspended from the trolley B of mass $m_B$. If the system is released from rest at $\theta = 0$, determine the velocity $v_B$ of the trolley and tension in the string when $\theta = 90°$. Friction is negligible.



**9.** A ball with initial speed 10m/s collides elastically with two other identical ball whose centres are on a line perpendicular to the initial velocity and which are initially in contact with each other. All the three ball are lying on a smooth horizontal table. The first ball is aimed directly at the contact point of the other two balls All the balls are smooth. Find the velocities of the three balls after the collision.

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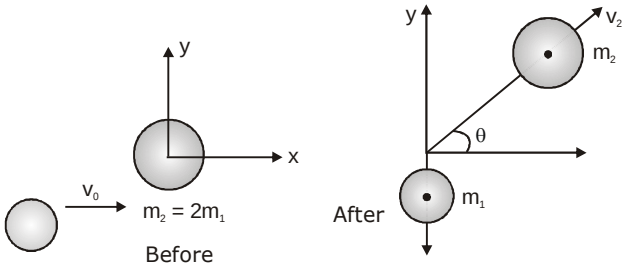
**10.** A mass $m_1$ with initial speed $v_0$ in the positive x-direction collides with a mass $m_2 = 2m_1$ which is initially at rest at the origin, as shown in figure. After the collision $m_1$ moves off with speed $v_1 = v_0/2$ in the negative y-direction, and $m_2$ moves off with speed $v_2$ at angle $\theta$.

(A) Find the velocity (magnitude and direction) of the center of mass before the collision, as well as its velocity after the collision.

(B) Write down the x and y-components of the equation of conservation of momentum for the collision.

(C) Determine $\tan\theta$, and find $v_2$ in terms of $v_0$.

(D) Determine how much (if any) energy was gained or lost in the collision, and state whether the collision was elastic or inelastic.




**11.** A cart is moving along +x direction with a velocity of 4m/s. A person in the cart throws a stone with a velocity of 6m/s relative to himself. In the frame of reference of the cart the stone is thrown in y-z plane making an angle of 30° with the vertical z-axis. At the highest point of its trajectory, the stone hits an object of equal mass hung vertically from branch of a tree by means of a string of length L. A completely inelastic collosion occurs, in which the stone gets embedded in the object. Determine

(a) the speed of the combined mass immediately after collision with respect to an observer on the ground.

(b) the length L of the string such that tension in the string becomes zero when the string becomes horizontal during the subsequent motion of the combined mass.

**12.** Twp equal sphere of mass 'm' are suspended by vertical strings so that they are in contact with their centres at same level. A third equal spheres of mass m falls vertically and strikes the other two simultaneously so that their centres at the instant of impact form an equilateral triangle in a vertical plane. If u is the velocity of m just before impact, find the velocities just after impact and the impulsive tension of the strings.