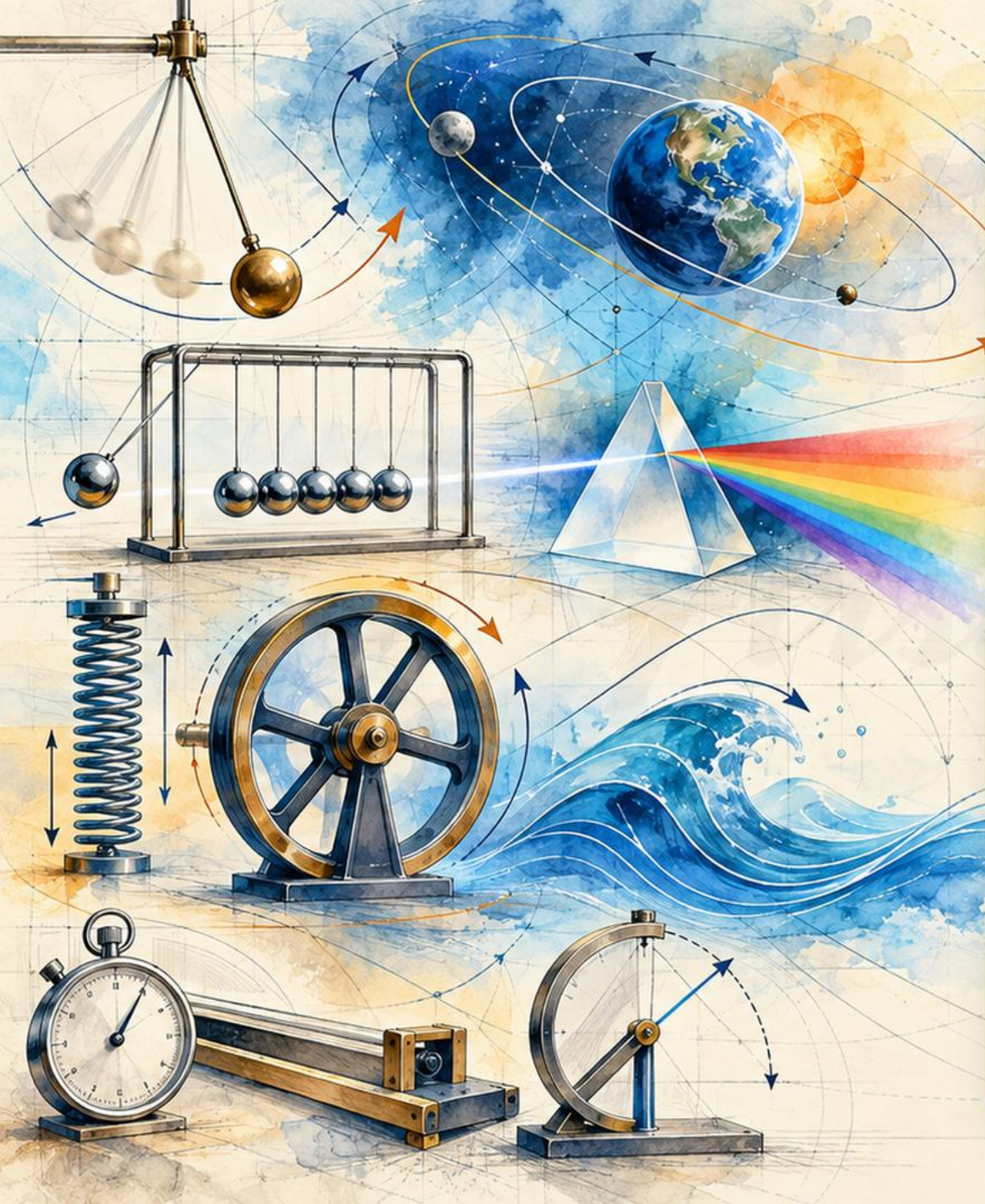




PHYSICS • CLASS 11

6

CHAPTER

System of Particles and Rotational Motion

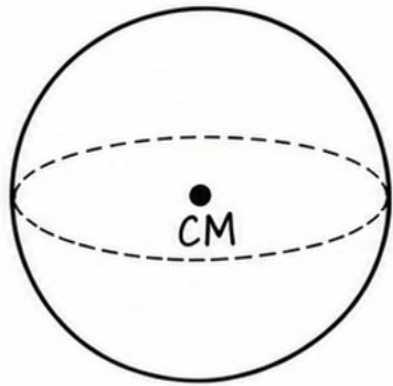
NCERT SOLUTIONS

EXERCISE SOLUTION: QUESTION 6.1

Locate the centre of mass of a sphere, cylinder, ring and cube, each of uniform mass density. Must the centre of mass lie within the material of a body?

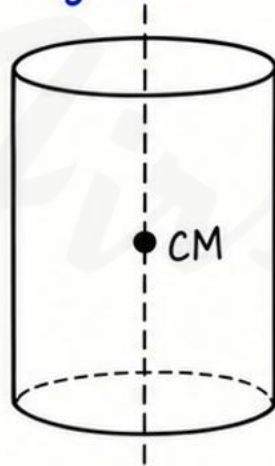
(i) Sphere

At its geometrical centre.



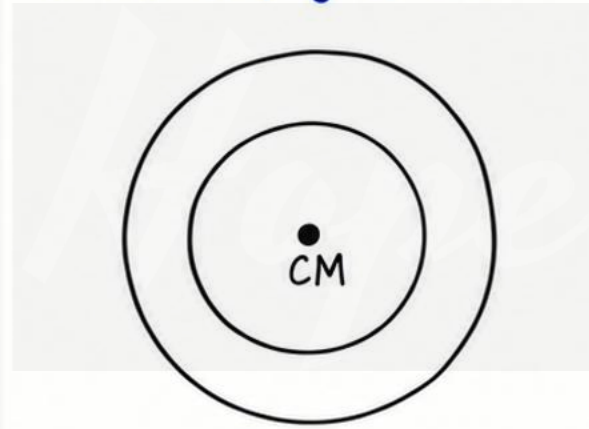
(ii) Cylinder

At the midpoint of its symmetry axis.



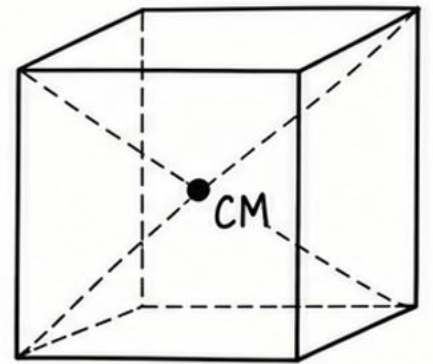
(iii) Ring

At the centre of the ring, in its empty space.



(iv) Cube

At the intersection of its body diagonals.



Solution: For a body of uniform mass density, symmetry ensures that equal amounts of mass are distributed on opposite sides of the centre. Hence, the centre of mass is located at the point of symmetry indicated above for each body.

Answer: No. The centre of mass need not lie in the body's material.

The ring is an example already given in this question.

EXERCISE SOLUTION: QUESTION 6.2

In HCl, the nuclei are separated by $1.27 \text{ \AA}$. A chlorine atom has 35.5 times the mass of a hydrogen atom. Nearly all atomic mass is in the nuclei. Find the approximate centre of mass.
 $1 \text{ \AA} = 10^{-10} \text{ m}$.

Answer:

Take the hydrogen nucleus as the origin and the positive axis toward chlorine.

$$m_H = m$$

$$m_{Cl} = 35.5m$$

$$x_H = 0$$

$$x_{Cl} = 1.27 \text{ \AA}$$

The position of the centre of mass is

$$X_{CM} = \frac{m_H x_H + m_{Cl} x_{Cl}}{m_H + m_{Cl}}.$$

Substituting the values,

$$\begin{aligned} X_{CM} &= \frac{m \times 0 + 35.5m \times 1.27}{36.5m} \text{ \AA} \\ &= 1.2352 \text{ \AA} \approx 1.24 \text{ \AA}. \end{aligned}$$

Distance of the centre of mass from the chlorine nucleus is

$$\begin{aligned} 1.27 - 1.2352 &= 0.0348 \text{ \AA} \\ &= 3.48 \times 10^{-12} \text{ m}. \end{aligned}$$

Hence, CM is $3.48 \times 10^{-12} \text{ m}$ from the chlorine nucleus toward hydrogen.

It lies between the nuclei, much closer to the heavier chlorine nucleus.

EXERCISE SOLUTION: QUESTION 6.3

Q. A child sits at one end of a long trolley moving uniformly at speed V on a smooth horizontal floor. If the child gets up and runs about in any manner, what is the speed of the centre of mass of the trolley-child system?

Answer:

Consider the child and trolley together. The floor is smooth, so there is no external horizontal force. Forces between the child and trolley are internal to this system.

$$F_{\text{external, horizontal}} = 0.$$

$$\frac{dP_{\text{horizontal}}}{dt} = 0.$$

Therefore the total horizontal momentum remains equal to its initial value.

Let the combined mass be M .

$$P_{\text{initial}} = MV.$$

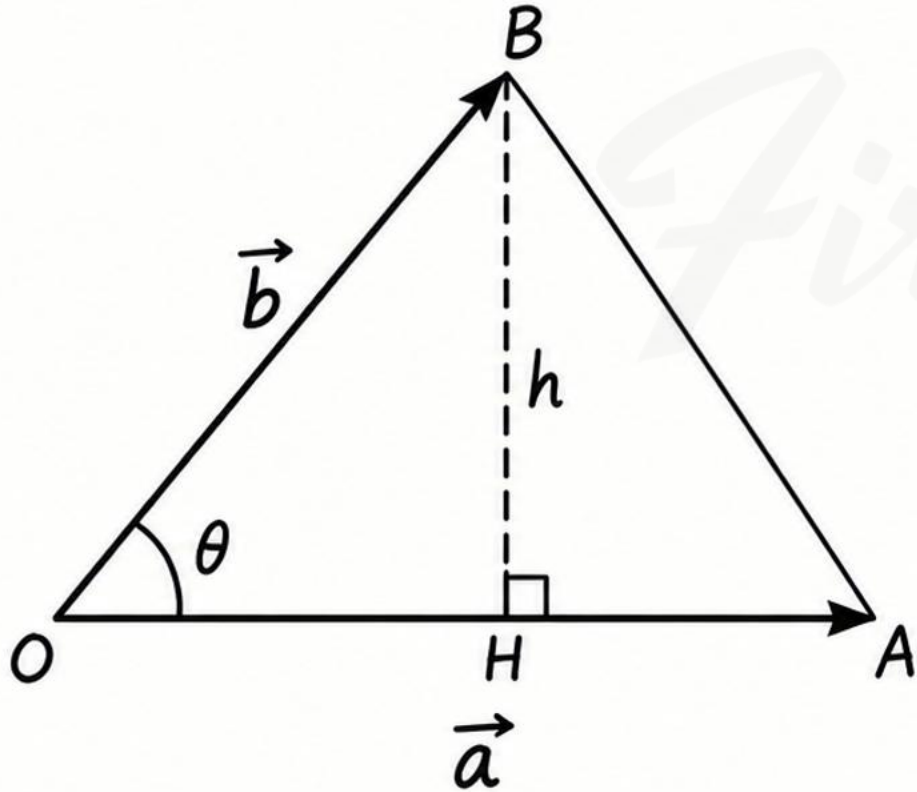
$$P_{\text{final}} = M V_{\text{CM}}.$$

$$M V_{\text{CM}} = MV \Rightarrow V_{\text{CM}} = V.$$

The child and trolley may change their individual velocities, but their combined centre of mass continues at the original constant speed and in the original horizontal direction.

EXERCISE SOLUTION: QUESTION 6.4

Question: Show that the area of the triangle formed between vectors $\vec{a}$ and $\vec{b}$ is half the magnitude of $\vec{a} \times \vec{b}$.



Solution:

Let the angle between the two vectors be θ .

Base of the triangle (OA) = $|\vec{a}|$.

Height of the triangle (BH) = $h = |\vec{b}| \sin \theta$.

Area of the triangle formed between the vectors is

$$\begin{aligned}\text{Area} &= \frac{1}{2} \times \text{base} \times \text{height} \\ &= \frac{1}{2} |\vec{a}| |\vec{b}| \sin \theta.\end{aligned}$$

By the magnitude formula for a cross product:

$$|\vec{a} \times \vec{b}| = |\vec{a}| |\vec{b}| \sin \theta.$$

$$\text{Area of triangle} = \frac{1}{2} |\vec{a} \times \vec{b}|.$$



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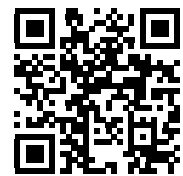


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