PRAYAS

JEE 2026

Physics

COM and System of particles

Lecture – 2

Manish Singh Tak (Masti Sir)

Topics to be covered

A Calculation of COM

B

C

D

ATDB.uno

$$\vec{F}_{ext.} = M\vec{a}_{cm} \qquad \vec{F}_{ext.} = \frac{d\vec{P}}{dt}$$

$$P_{System} = M\vec{V}_{cm}$$

$$\vec{a}_{cm} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + \cdots}{M}$$

$$\vec{V}_{cm} = \frac{m_1\vec{V}_1 + m_2\vec{V}_2 + \cdots}{M}$$

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \cdots}{M}$$

$$X_{cm} = \frac{m_1x_1 + m_2x_2 + \cdots}{M}$$

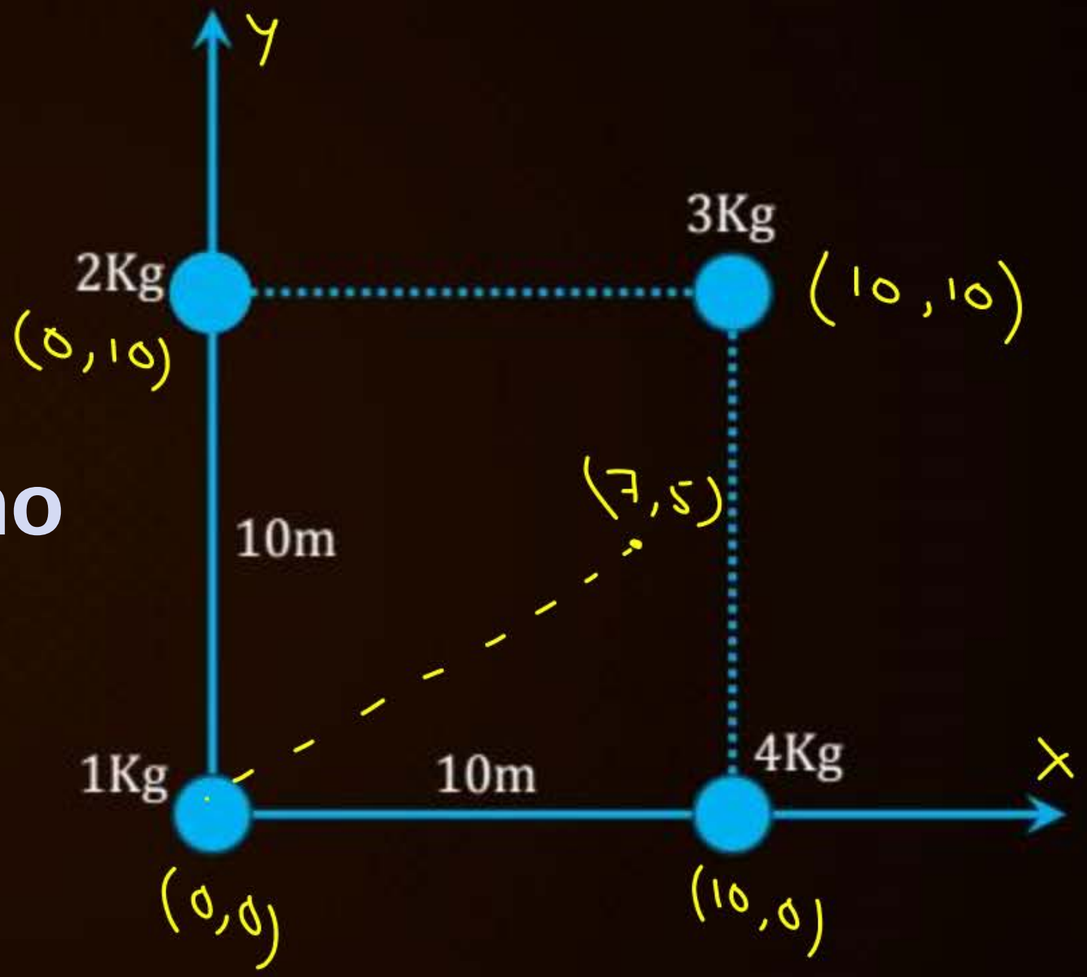
Question 11

4 particles of mass 1Kg, 2Kg, 3Kg and 4Kg are kept as shown. Find COM of system

$$X_{cm} = \frac{1(0)+2(0)+3(10)+4(10)}{10} = 7$$

$$y_{cm} = \frac{1(0)+2(10)+3(10)+4(0)}{10} = 5$$

(7, 5)



Question 12

4 particles of mass 1Kg, 2Kg, 3Kg and 4Kg are kept as shown. Find COM of system

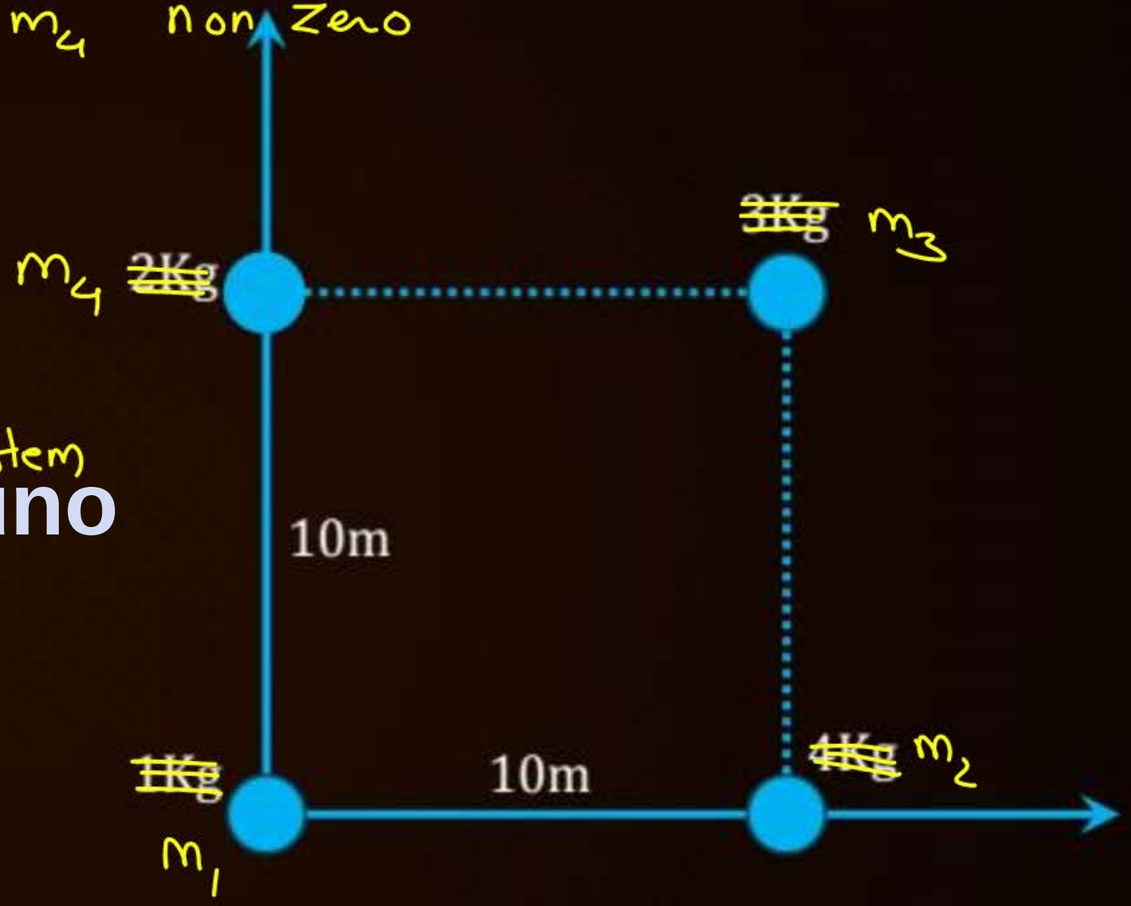
m_1, m_2, m_3, m_4 non Zero

$0 < X_{cm} < 10$

$0 < Y_{cm} < 10$

True

→ COM must lie within boundary of System



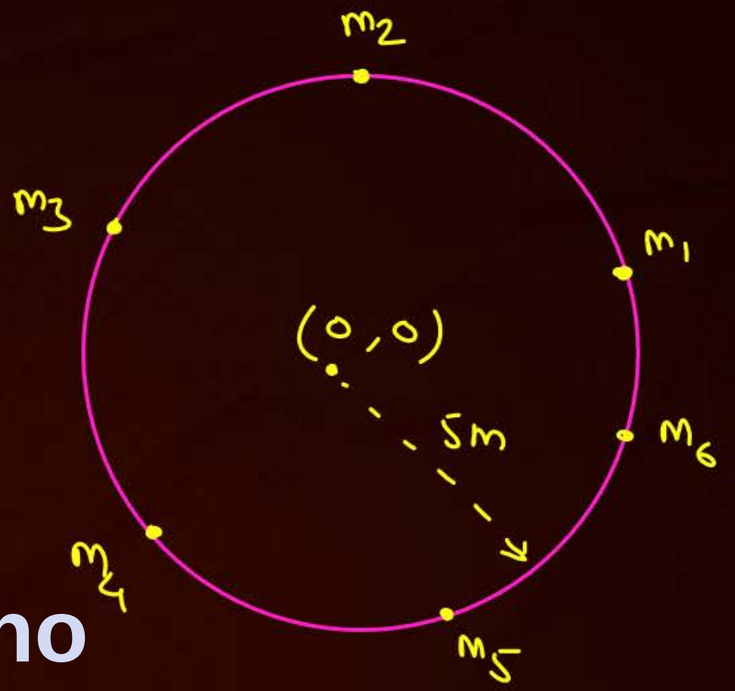
Q-3 for COM

$X_{cm}^2 + Y_{cm}^2 - 25$ Should be -ive

$X_{cm}^2 + Y_{cm}^2 < 25$

(A) True

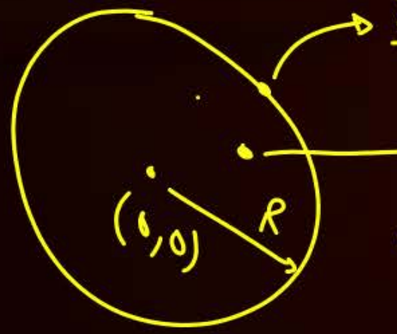
(B) False



Mass → non zero

atleast 2 particles

Particles are on Circumference



$x^2 + y^2 = R^2$

$x^2 + y^2 < R^2 \Rightarrow x^2 + y^2 - R^2 < 0$

$x^2 + y^2 > R^2 \Rightarrow x^2 + y^2 - R^2 > 0$

$r = \sqrt{x^2 + y^2}$

$r < R$ inside

$r = R$ on Circle

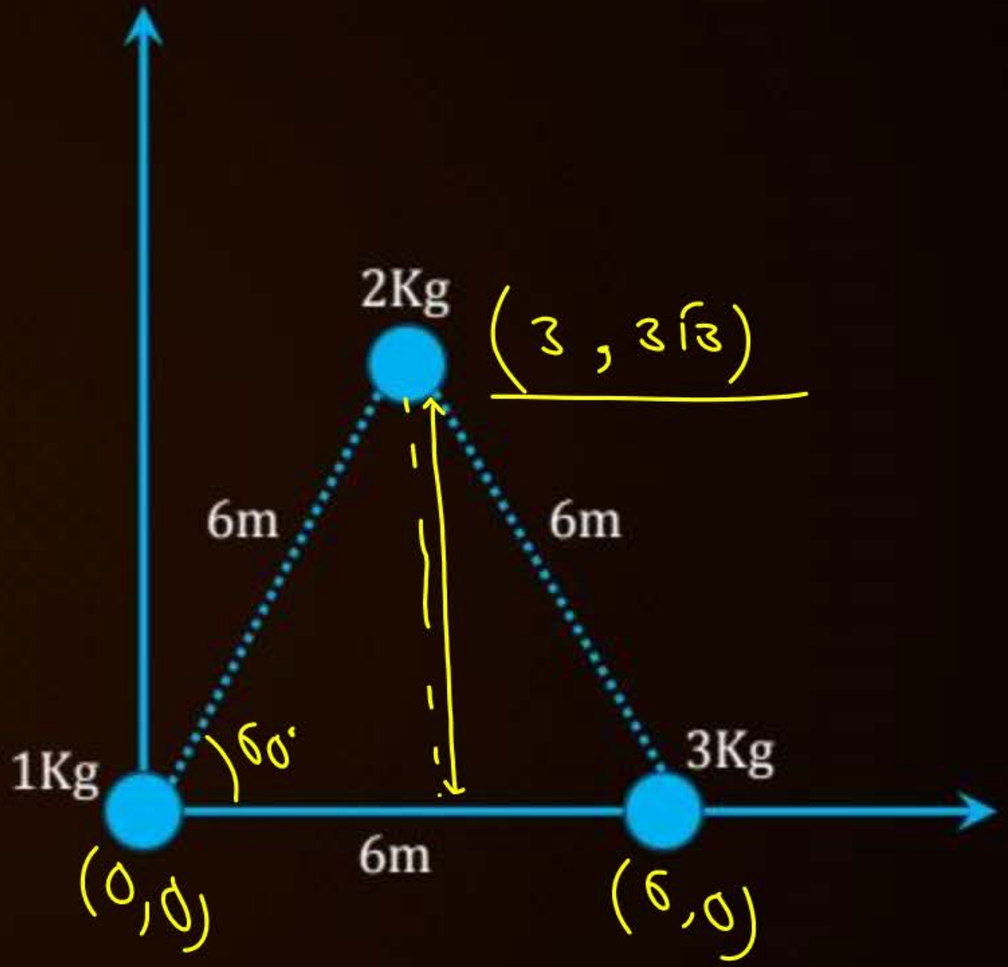
$r > R$ outside

Question

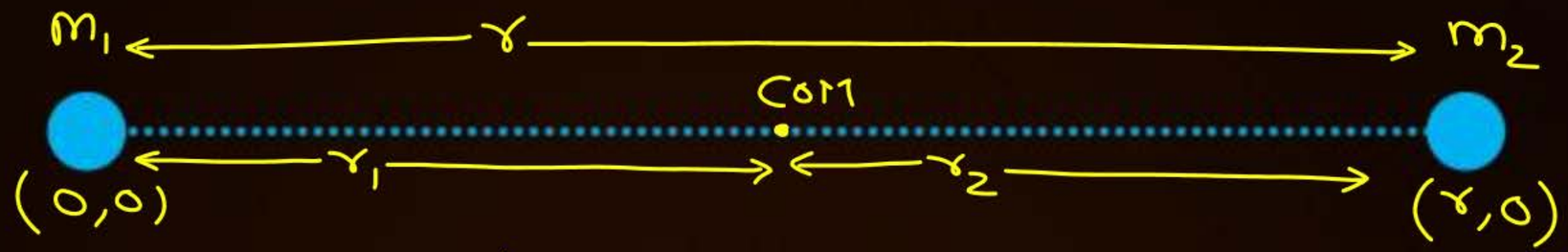
3 particles of mass 1Kg, 2Kg, 3Kg are kept as shown. Find COM of system

$$X_{cm} = \frac{1(0)+2(3)+3(6)}{6} = 4$$

$$Y_{cm} = \frac{1(0)+2(3\sqrt{3})+3(0)}{6} = \sqrt{3}$$



COM of 2 particles system



→ COM of 2 particles System is always lies on their line joining

→ COM is close to heavy mass

$$y_{cm} = \frac{m_1(0) + m_2(0)}{m_1 + m_2} = 0$$

$$x_{cm} = \frac{m_2(r) + m_1(0)}{m_1 + m_2} = \frac{m_2 r}{m_1 + m_2}$$

$$r_1 = \frac{m_2 r}{m_1 + m_2} \quad , \quad r_2 = \frac{m_1 r}{m_1 + m_2} \quad , \quad \frac{r_1}{r_2} = \frac{m_2}{m_1}$$

$$r \propto \frac{1}{m}$$

9-5| few particles are kept in x-y plane such that Com of System is at origin. one particle is kept on tive x-axis. which of following must true

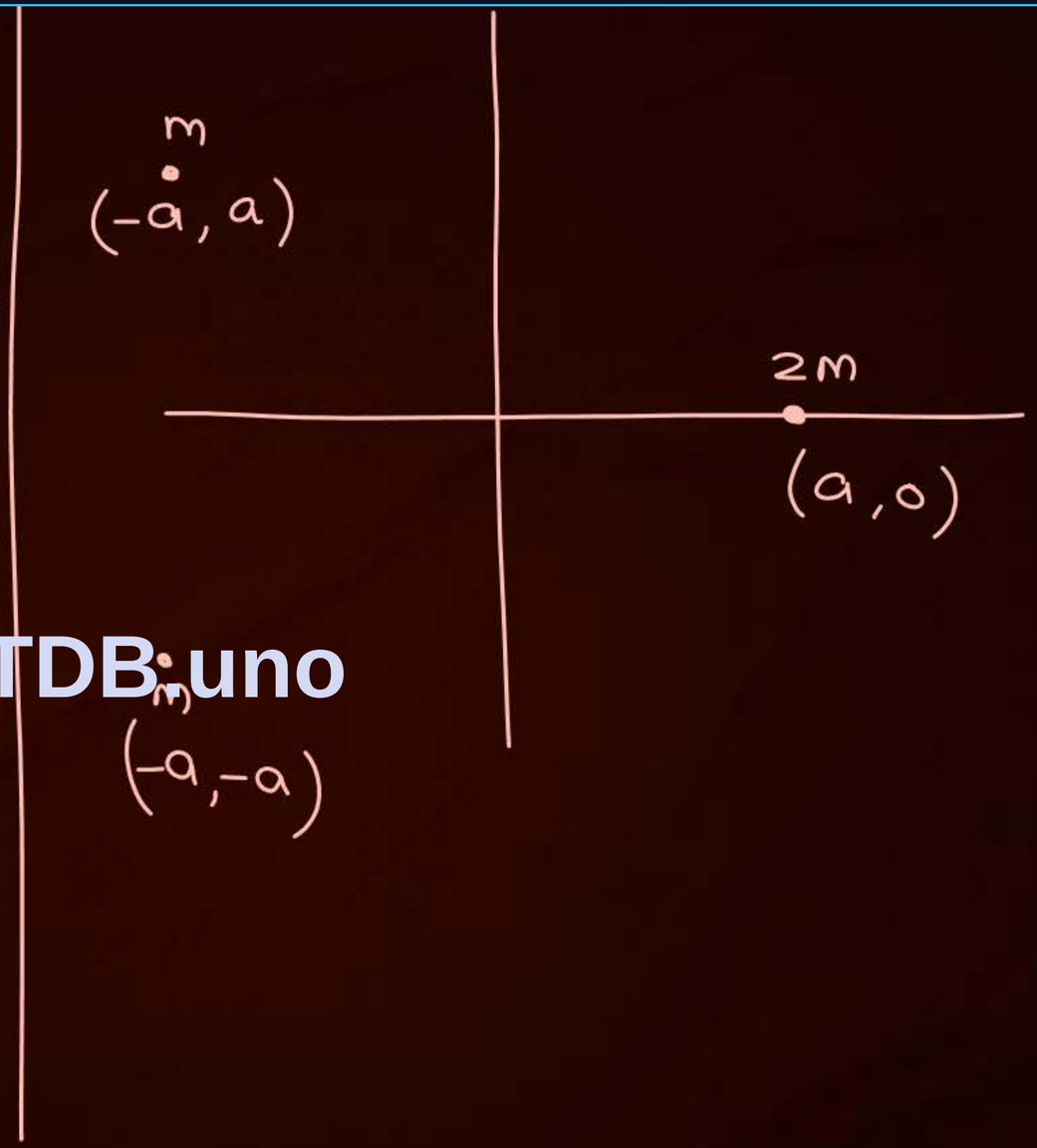
(A) atleast one particle is on -ive x-axis

(B) atleast one particle have -ive x-Coordinate

$X_1 \longrightarrow$ +ive

$X_{cm} = 0$

$$\frac{m_1 x_1 + m_2 x_2 + \cdots}{M} = X_{cm} = 0$$

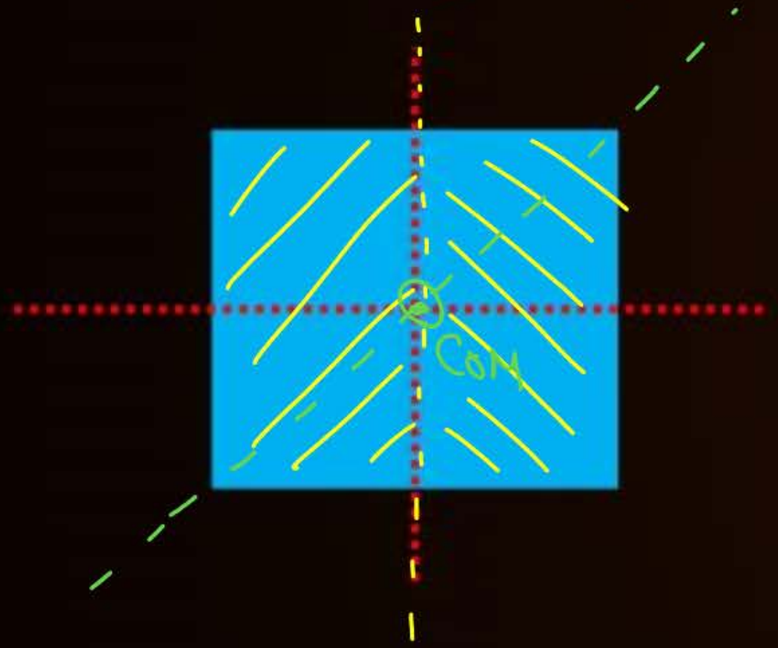


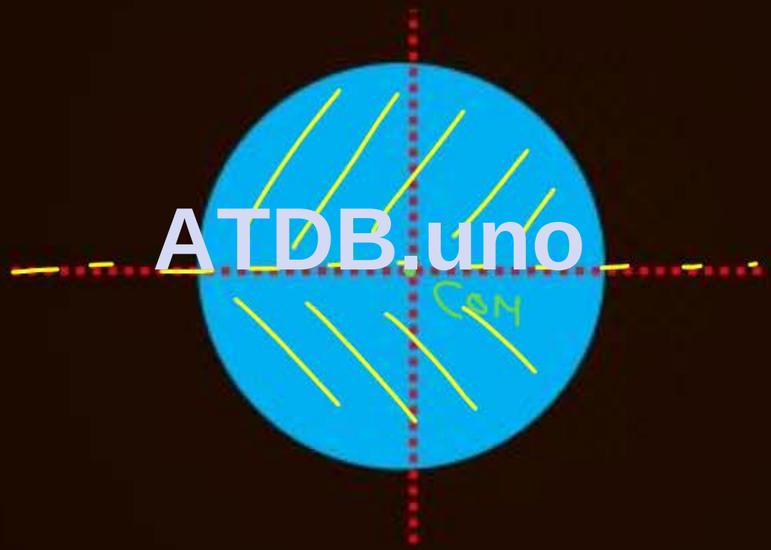
COM of Uniform mass distribution (Object)

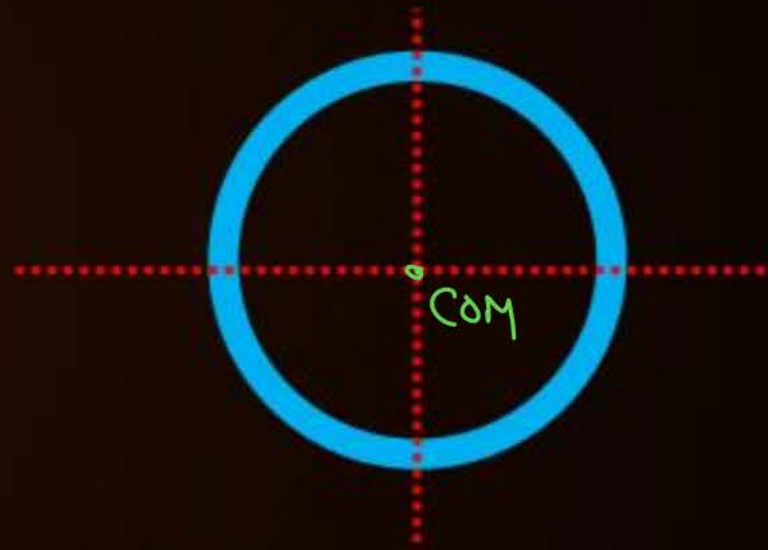
For uniform mass distribution COM lies on line of symmetry

↳ is at Geometrical Center of object

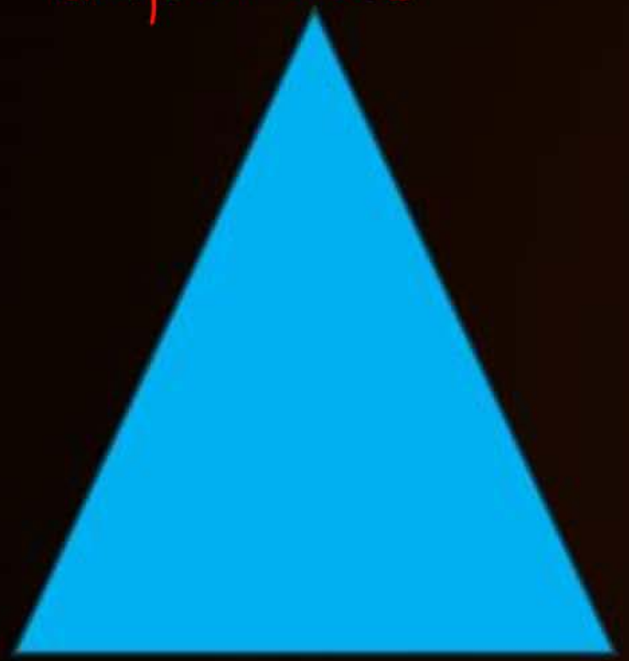
line of Symmetry → line about which both parts of object are mirror image

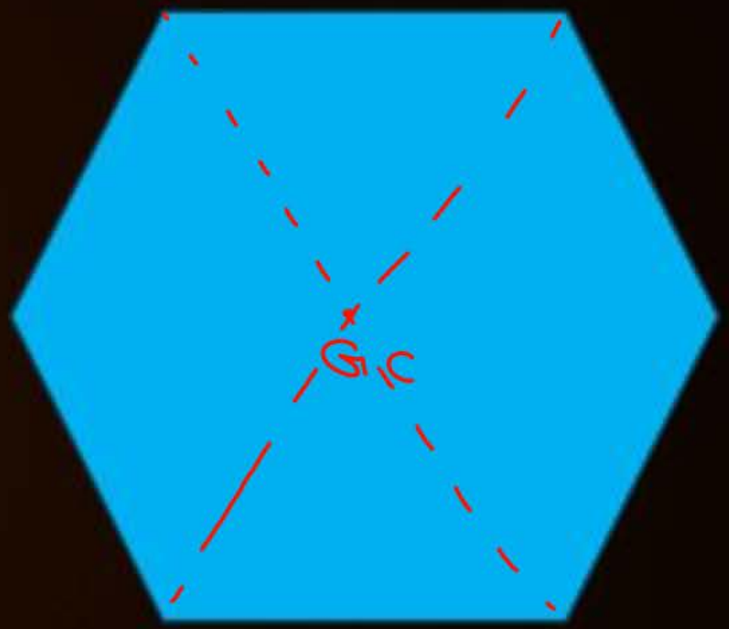






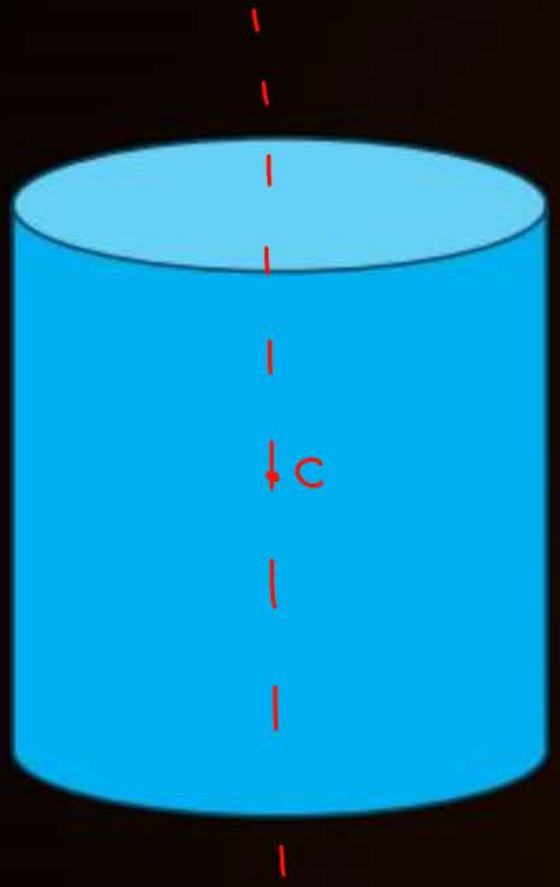
triangle
Uniform mass

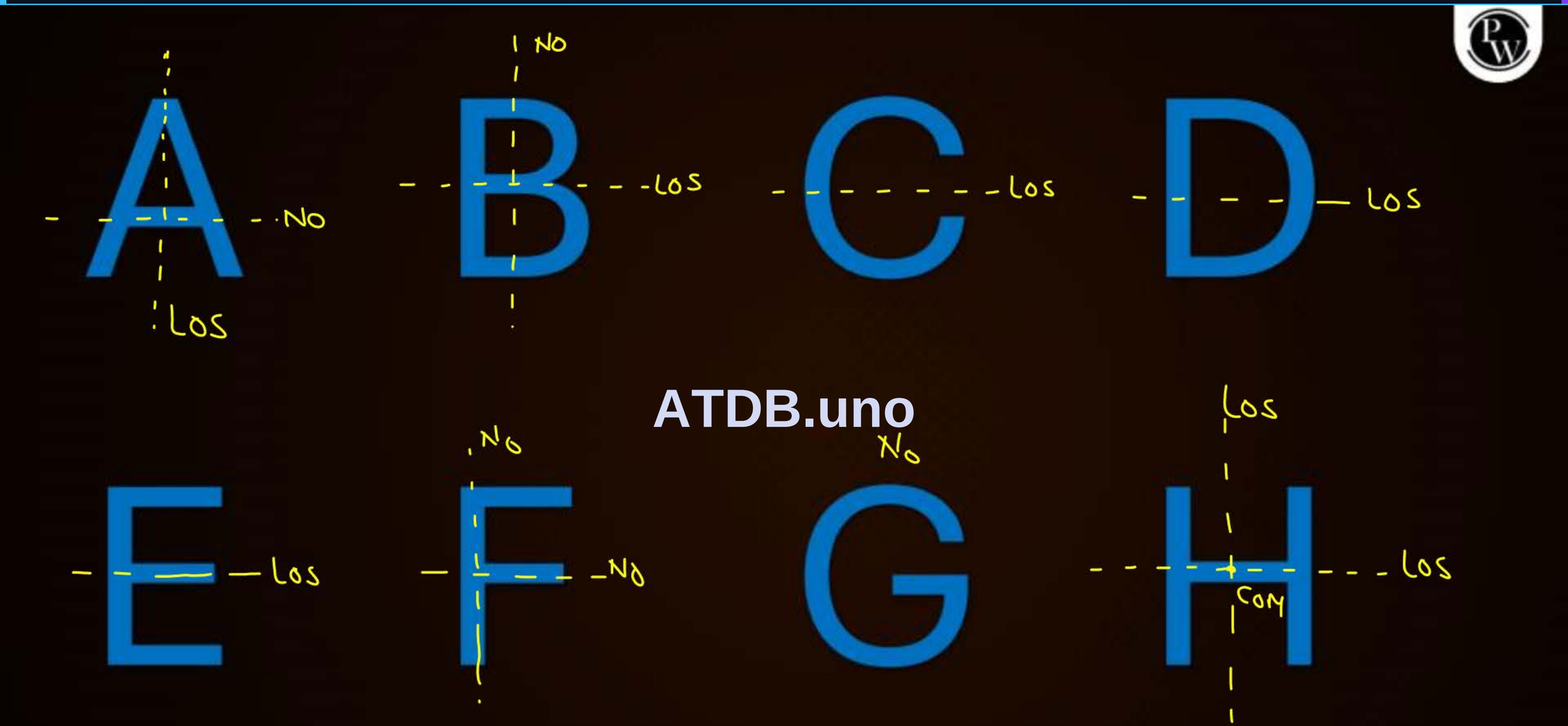


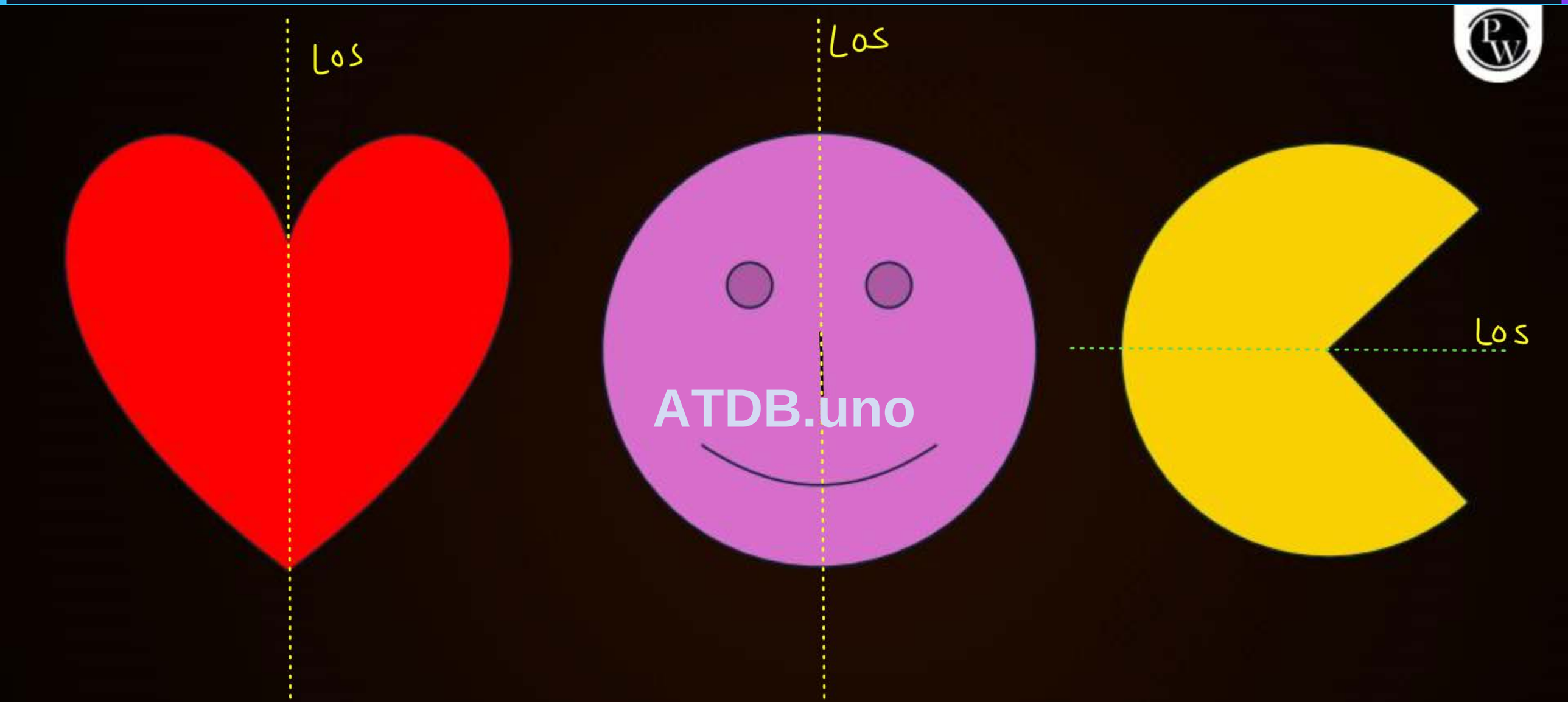


Centroid ≡ COM

True ✓
false







Linear mass density (λ)

mass per unit length

$$\lambda = \frac{m}{\ell} = \frac{dm}{d\ell}$$

$$dm = \lambda\, d\ell$$

m, ℓ (uniform)

Rod $\lambda = \frac{m}{\ell}$

m, R (uniform)

$\lambda = \frac{m}{2\pi R}$

Ring

Surface mass density (σ)

mass per unit area

$$\sigma = \frac{\text{mass}}{\text{Area}} = \frac{dm}{dA}$$

$$dm = \sigma\, dA$$

Volume mass density (ρ)

mass per unit volume

$$\rho = \frac{m}{V} = \frac{dm}{dV}$$

$$dm = \rho \cdot dV$$

Question — 6

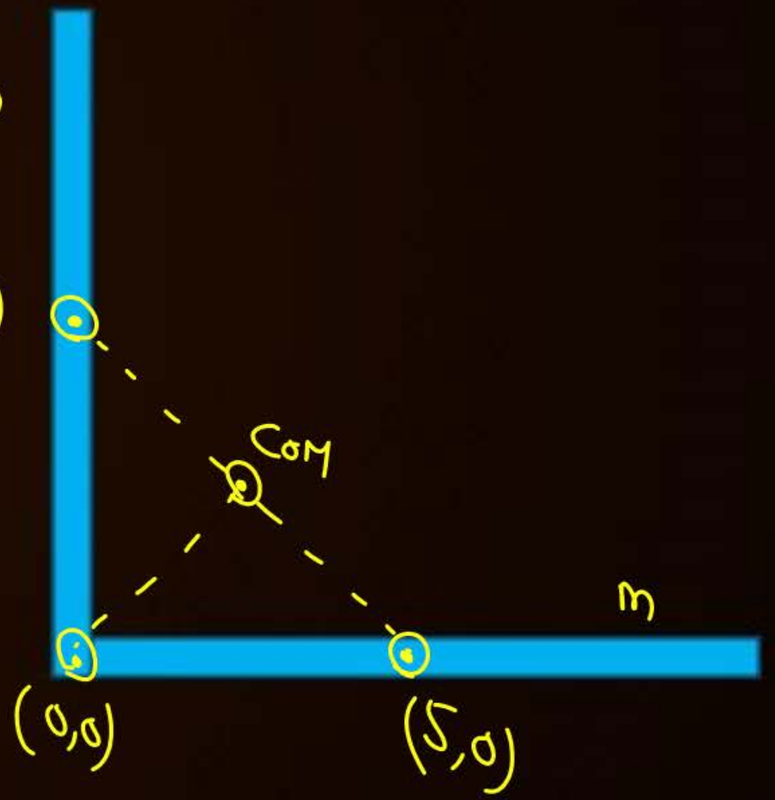
Two identical rods of length 10m are attached as shown find distance of com of system from joint of both rods

$$x_{cm} = \frac{m(5)+m(0)}{2m} = \frac{5}{2}$$

$$y_{cm} = \frac{m(0)+m(5)}{2m} = \frac{5}{2}$$

$$\text{distance} = \sqrt{\left(\frac{5}{2}\right)^2 + \left(\frac{5}{2}\right)^2}$$

$$\frac{5}{2}\cdot\sqrt{2} = \frac{5}{\sqrt{2}}\ m$$



Question - 1

Two identical rods of length 10m are attached as shown find distance of com of system from joint of both rods

(A) 5 m

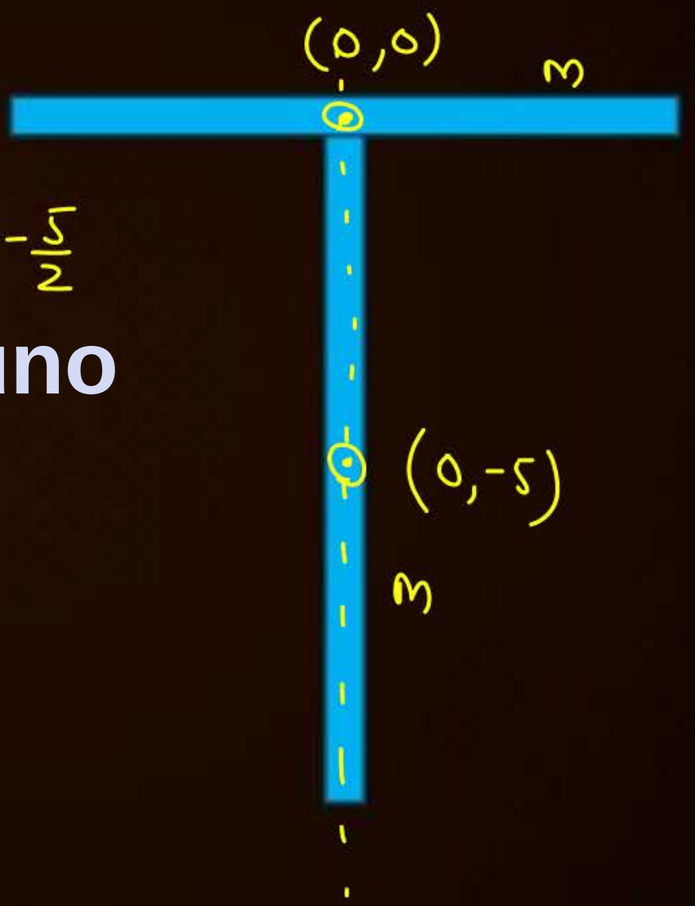
(B) 2.5 m

(C) 10 m

(D) $\frac{5}{4}$ m

$x_{cm} = 0$

$y_{cm} = \frac{m(0) + m(-5)}{2m} = -\frac{5}{2}$



Question – 8

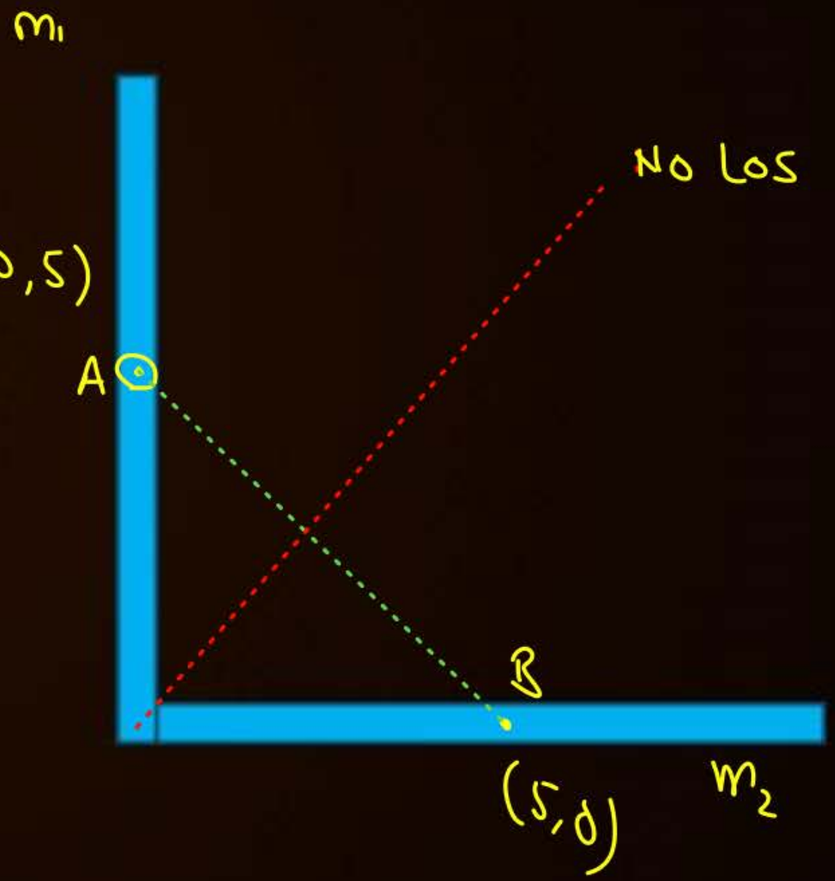
Two rods of length 10m are attached as shown find Equation of curve at which com of system lies, take origin at joint of both rods and X and y axis along rods (remember both rods may have different masses

COM must lie on line Segmant AB

Eqn of line $y = mx + c$

$y = -1(x) + 5 \Rightarrow x + y = 5$

$(0, x<5, 0<y<5)$



Question – 5

Two rods of length 10m are attached as shown find possible co-ordinate of com of system, take origin at joint of both rods and X and y axis along rods (remember both rods may have different masses

(A) (1, 4)

(B) (2, 3)

(C) (2·5, 2·5)

(D) (−1, 6)

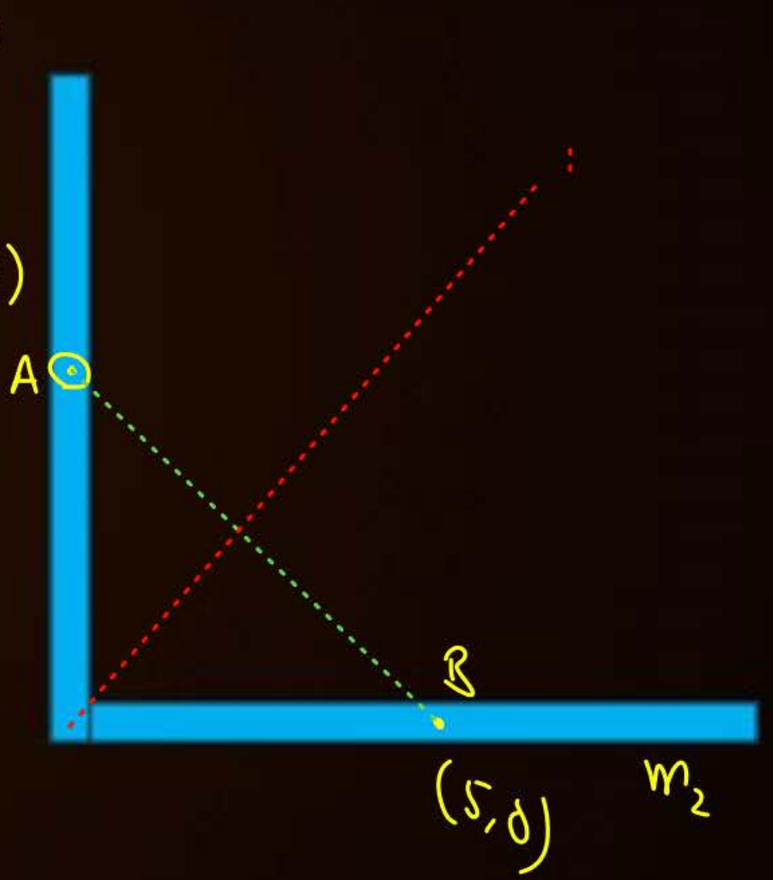
Com lies on

$X+y=5$

(1, 4) (2, 3) (2·5, 2·5) (0, 5)

(−1, 6)

X

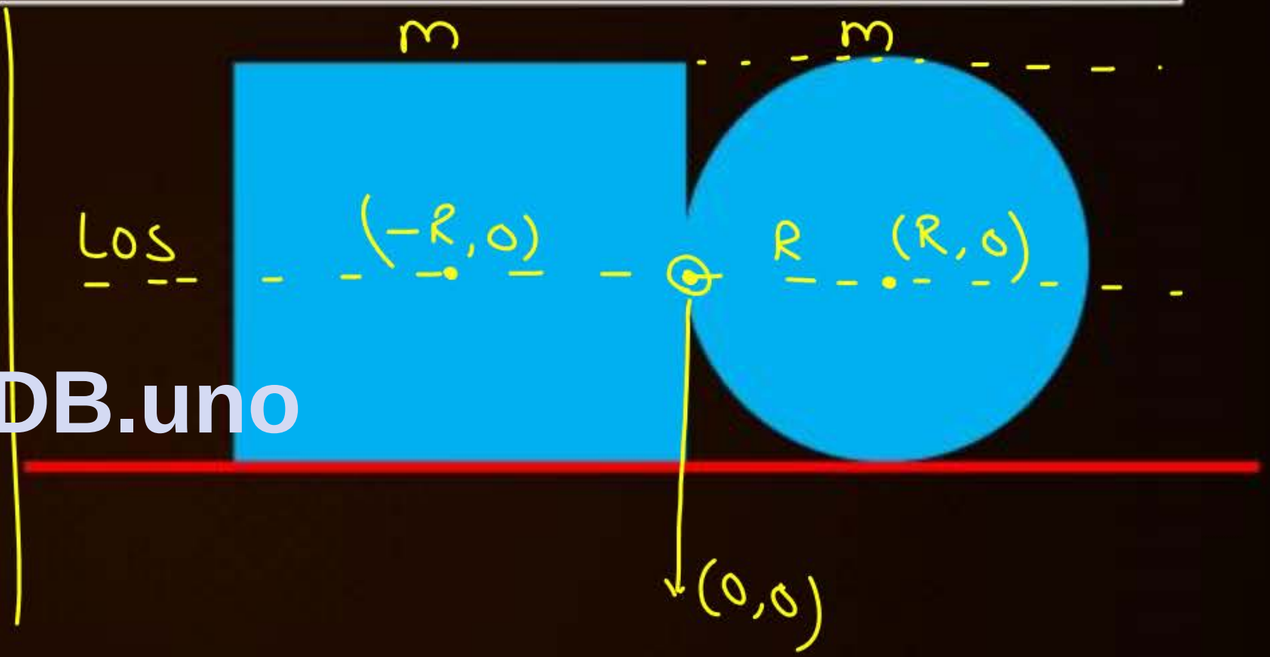


Question – 18

A square of side 2R and a disc of radius R are kept in contact as shown. Find distance of COM of system from contact point. Given both objects have same mass

$$y_{cm} = 0$$

$$X_{cm} = \frac{m(R) + m(-R)}{2m} = 0$$



Question

A square of side $2R$ and a disc of radius R are kept in contact as shown. Find distance of COM of system from contact point. Given both object have same mass per unit area (made of same material and have same thickness)

Question -12

A rod of mass 4m and length 2R and a disc of mass m and radius R are kept in contact as shown. Find distance of COM of system from contact point

Question -13

A rod of length L have variable mass density $\lambda = aX+b$, where X is distancee from point A find (1) total mass of rod (2) COM from end A

hint

$$\text{mass} = \lambda(\text{length})$$

$$dm = \lambda dl$$

$$X_{cm} = \frac{\int x\,dm}{\int dm}$$