

PRAAYAS

JEE 2026

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Physics

COM and System of
particles

Lecture - 2

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Physics Wallah



Topics to be covered

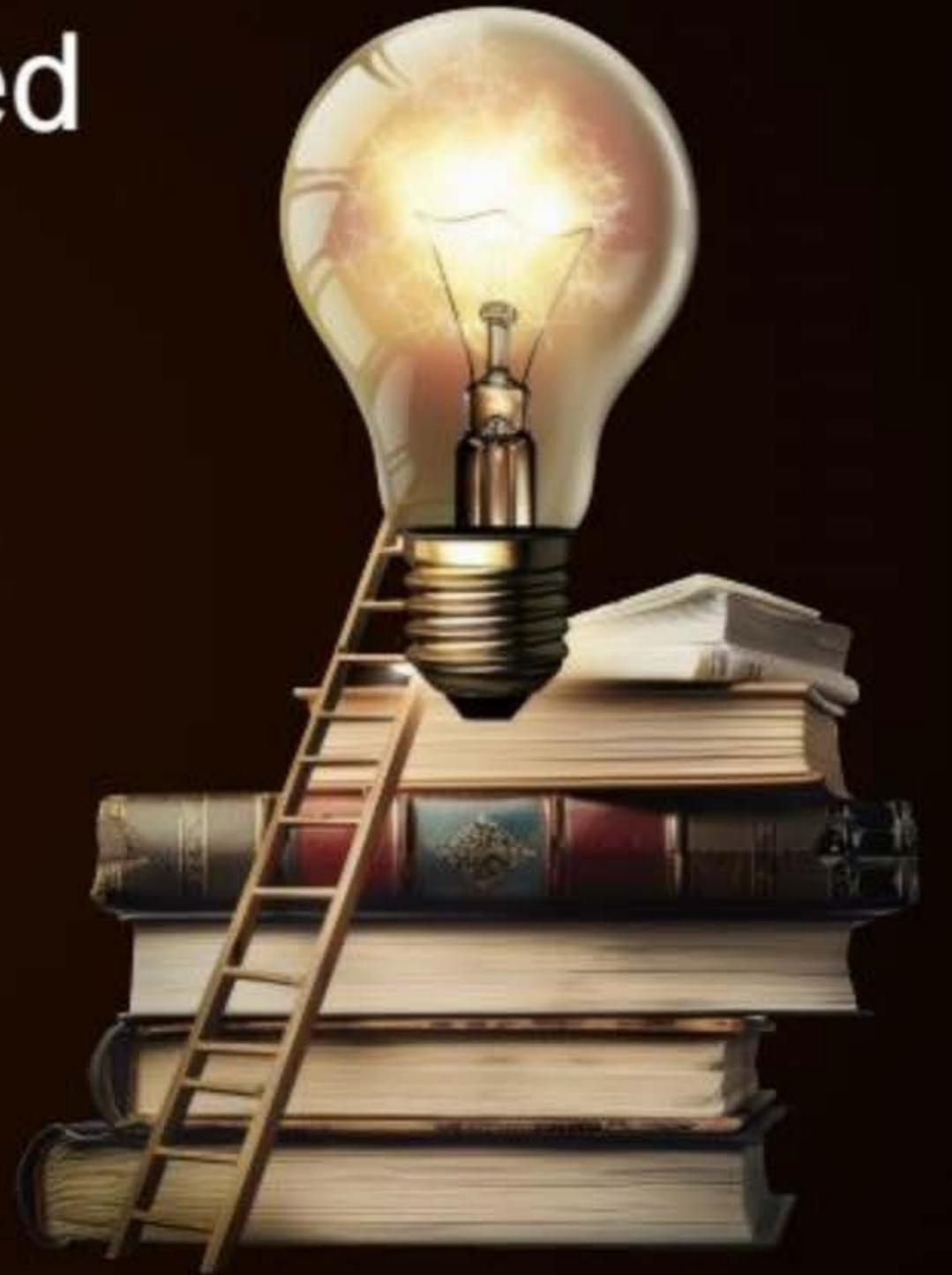
A Calculation of COM

B

C

D

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$$\star\star \boxed{\vec{F}_{\text{ext.}} = M \vec{a}_{\text{cm}}}$$

$$\vec{F}_{\text{ext.}} = \frac{d\vec{P}}{dt}$$

$$\star\star \boxed{P_{\text{system}} = M \vec{V}_{\text{cm}}}$$

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

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

$$\vec{Y}_{\text{cm}} = \frac{m_1 \vec{y}_1 + m_2 \vec{y}_2 + \dots}{M}$$

$$X_{\text{cm}} = \frac{m_1 x_1 + m_2 x_2 + \dots}{M}$$

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Question

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

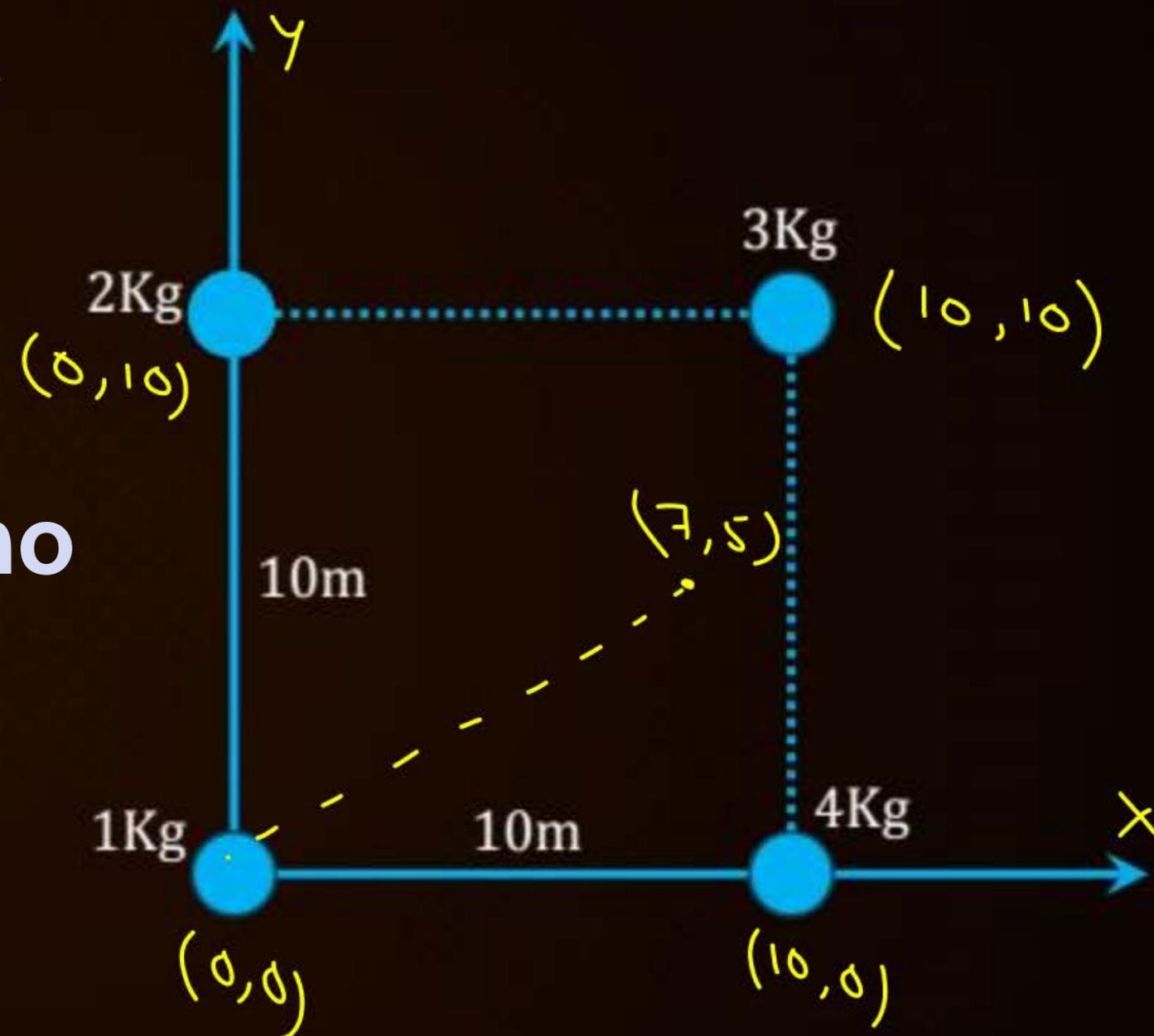


$$x_{cm} = \frac{1(0) + 2(0) + 3(10) + 4(10)}{10} = 7$$

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

(7, 5)

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Question

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

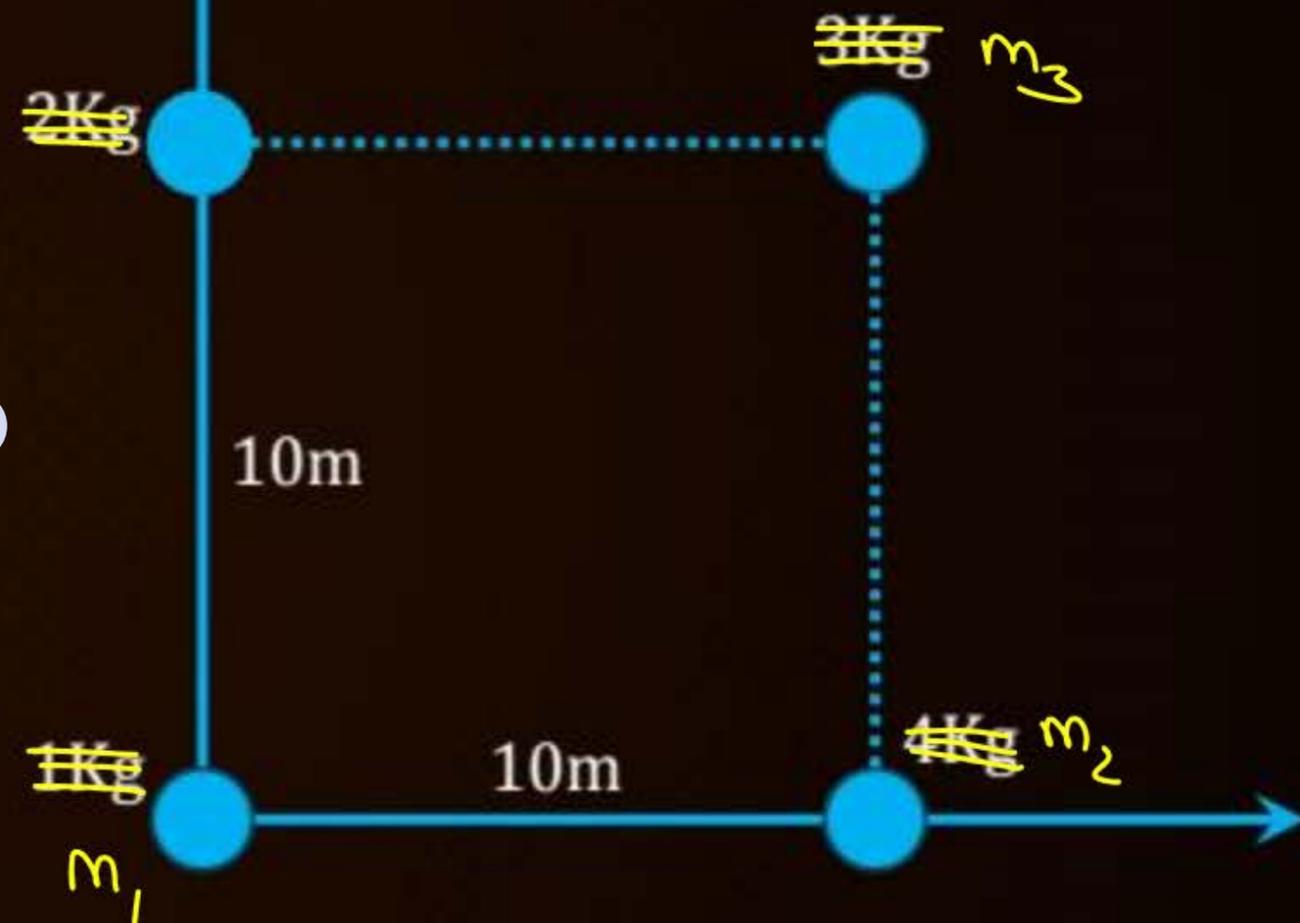
$$0 < X_{cm} < 10$$

$$0 < Y_{cm} < 10$$

True

→ COM must lie within boundary of System

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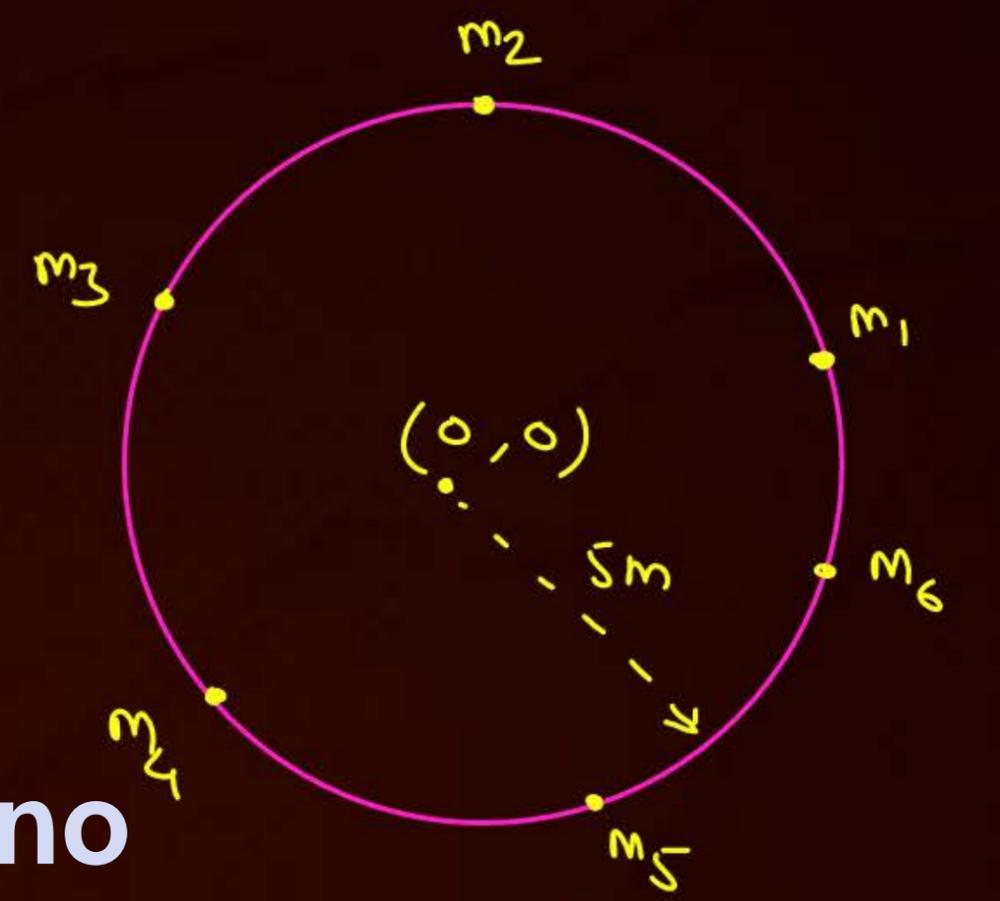
Q-3 for COM

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

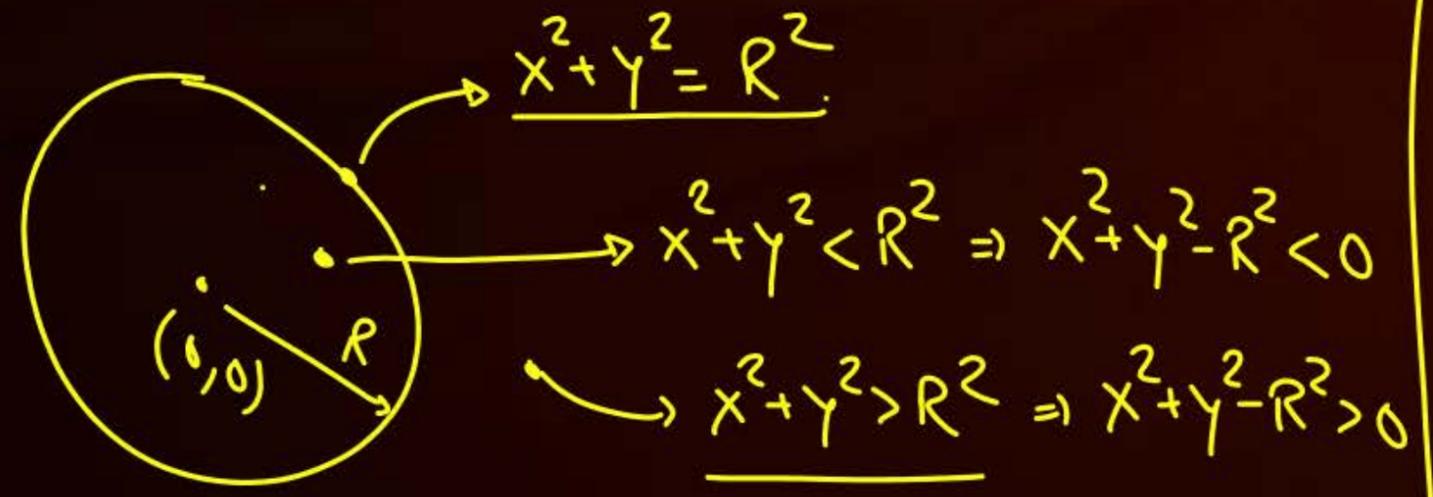
$X_{cm}^2 + Y_{cm}^2 < 25$

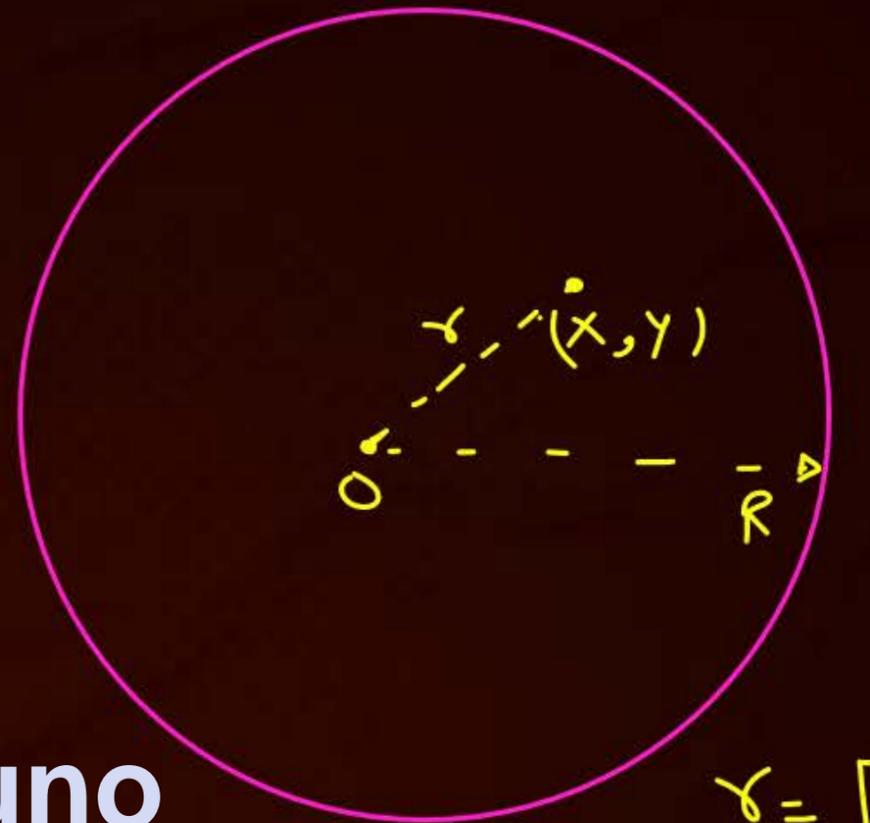
- (A) True
- (B) False

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mass \rightarrow non zero
 at least 2 particles
 Particles are on Circumference





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

$r < R$ inside

$r = R$ on Circle

$r > R$ outside

QUESTION

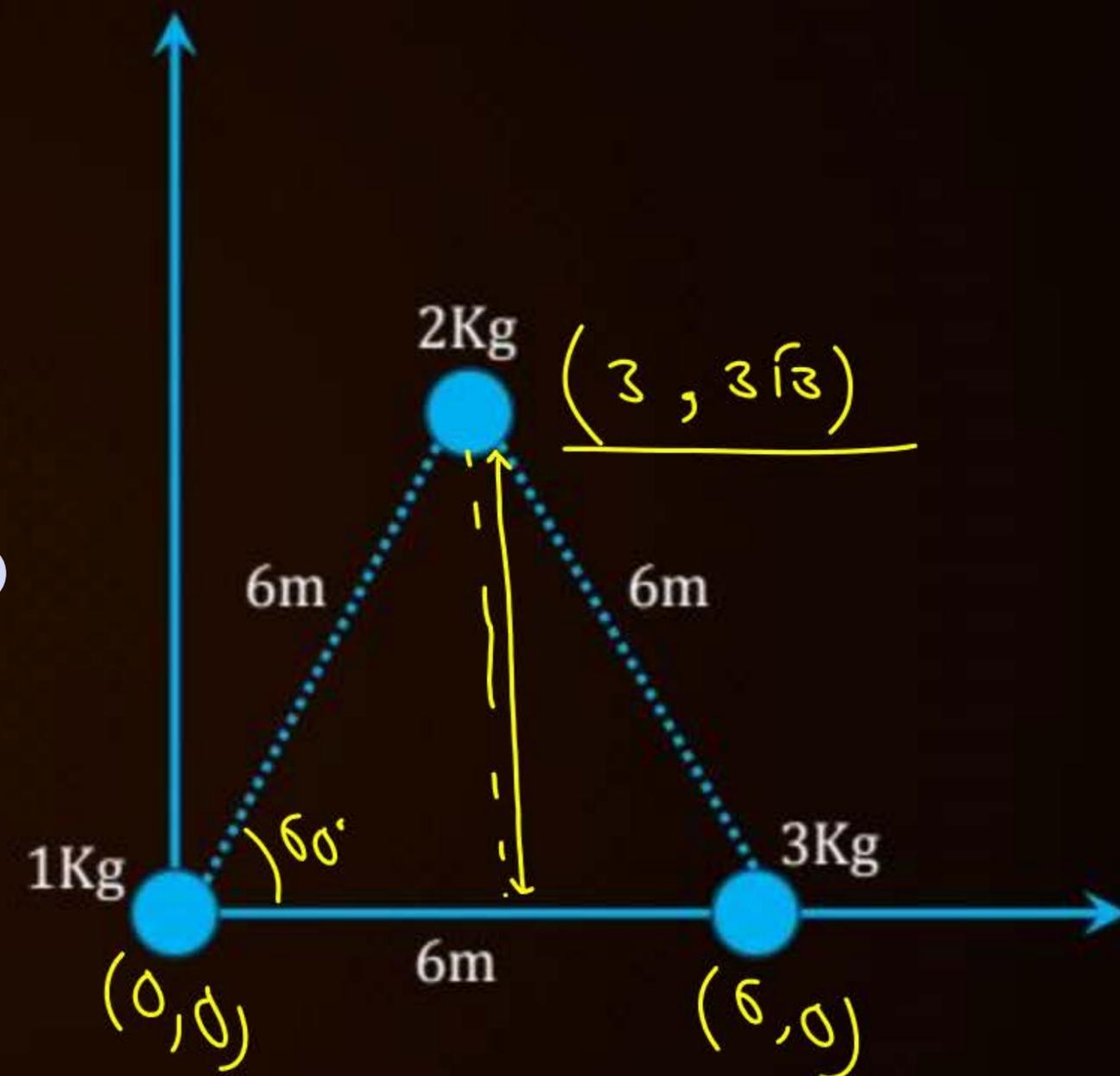
3 particles of mass 1Kg, 2Kg, 3Kg are kept as shown. Find COM of system



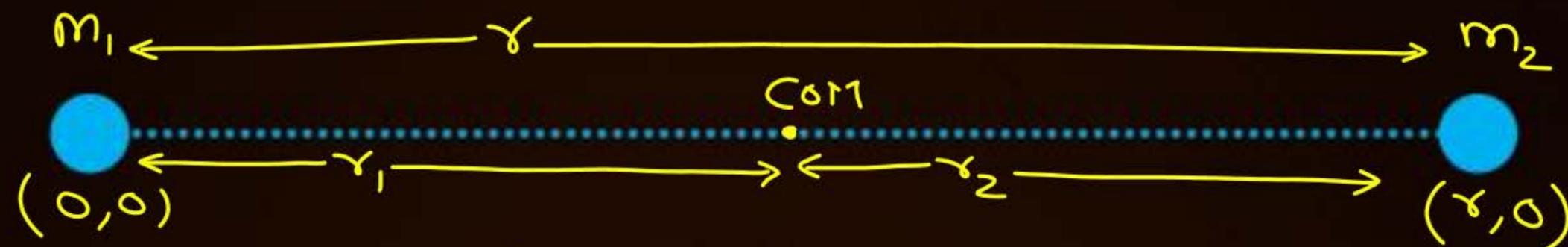
$$x_{cm} = \frac{1(0) + 2(3) + 3(6)}{6} = 4$$

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

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COM of 2 particles system



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

→ COM is close to heavy mass

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

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

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

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

Q-5

few particles are kept in $x-y$ plane such that
COM of system is at origin. one particle is kept on
+ive x -axis. which of following must true

- (A) at least one particle is on -ive x -axis ✓✓
- (B) at least one particle have -ive x -coordinate

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 m_1, m_2, \dots
 $X_1 \rightarrow \text{+ive}$

$$X_{cm} = 0$$

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

$$\begin{matrix} m \\ \bullet \\ (-a, a) \end{matrix}$$

 $2m$

$$\bullet \\ (a, 0)$$

$$\begin{matrix} m \\ \bullet \\ (-a, -a) \end{matrix}$$

$$(-a, -a)$$

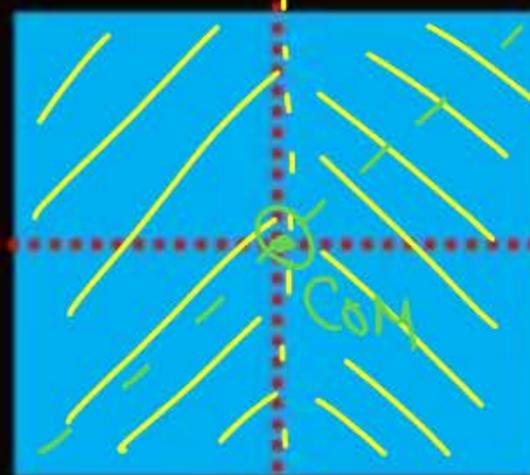
COM of Uniform mass distribution (Object)



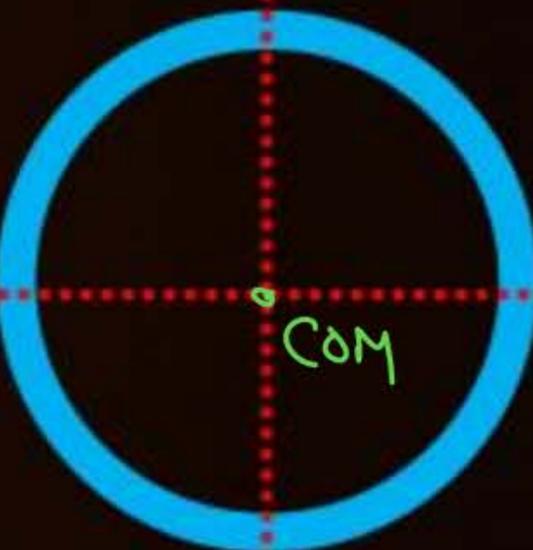
For uniform mass distribution COM lies on line of symmetry

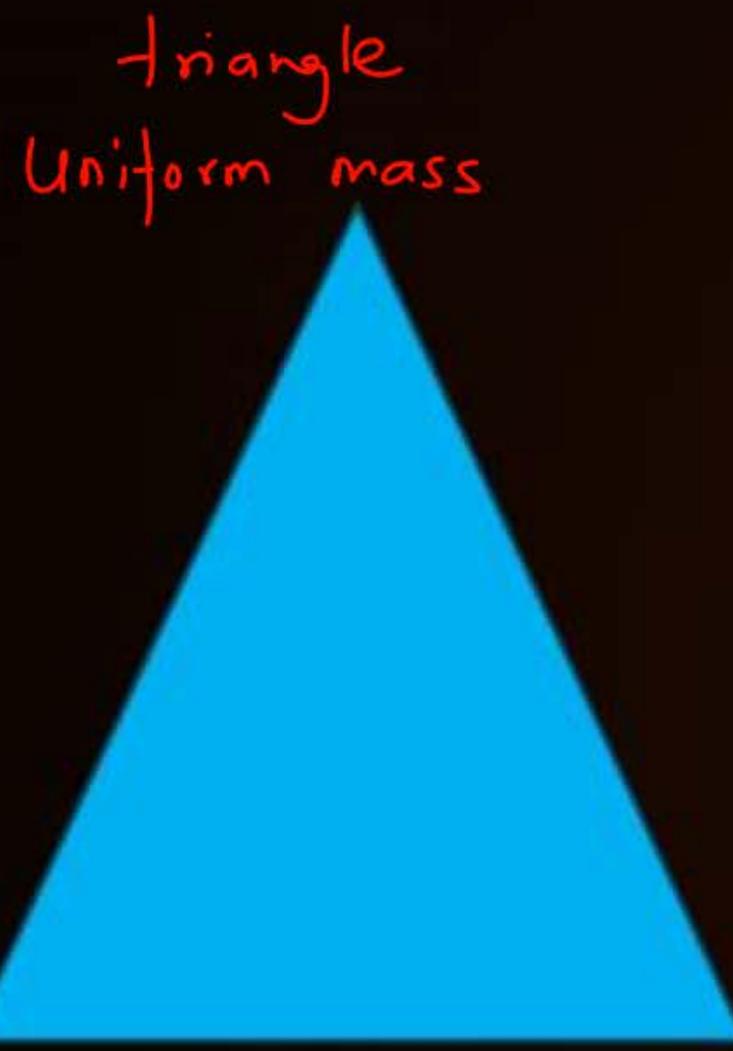
↳ is at Geometrical Center of object

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



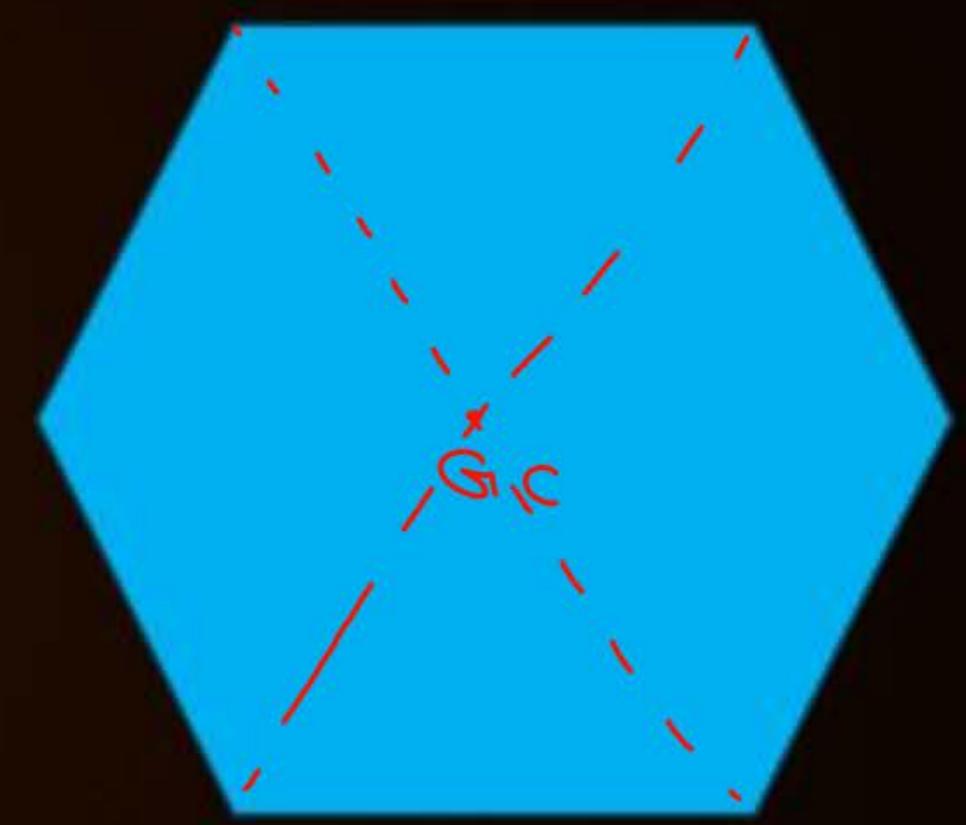
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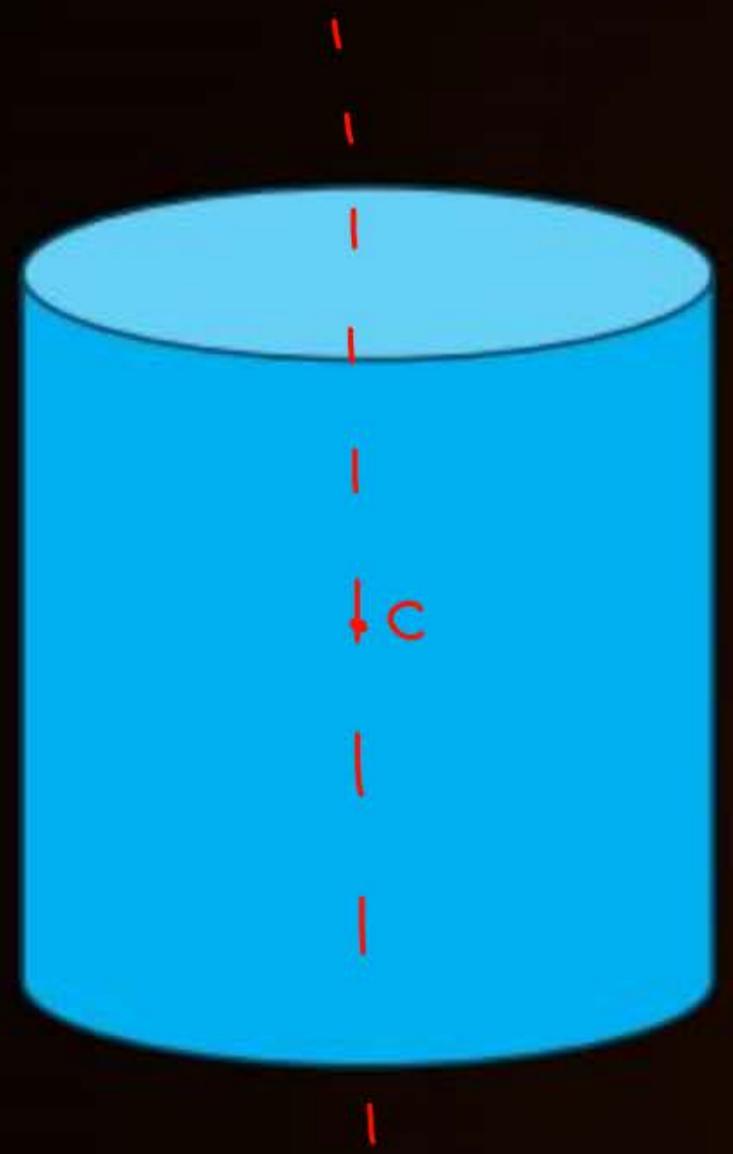




Centroid \equiv COM

True ✓
false





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A B C D

Handwritten annotations for A: Vertical dashed line with 'NO' above and 'LOS' below; horizontal dashed line with 'NO' to the right.

Handwritten annotations for B: Vertical dashed line with 'NO' above and 'LOS' below; horizontal dashed line with 'LOS' to the right.

Handwritten annotations for C: Horizontal dashed line with 'LOS' to the right.

Handwritten annotations for D: Horizontal dashed line with 'LOS' to the right.

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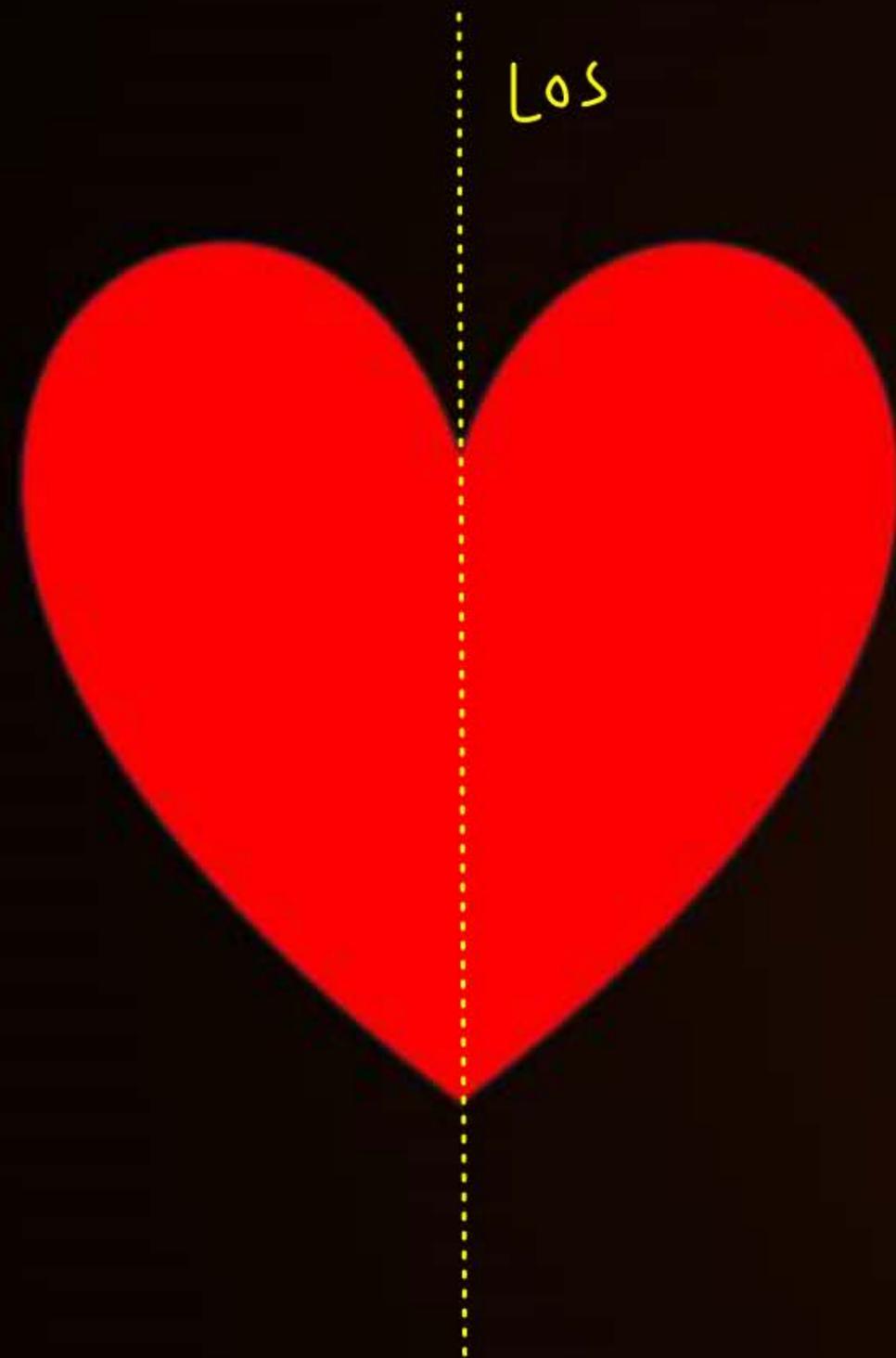
E F G H

Handwritten annotations for E: Horizontal dashed line with 'LOS' to the right.

Handwritten annotations for F: Vertical dashed line with 'NO' above and 'LOS' below; horizontal dashed line with 'NO' to the right.

Handwritten annotations for G: 'NO' written above the letter.

Handwritten annotations for H: Vertical dashed line with 'LOS' above and 'COM' below; horizontal dashed line with 'LOS' to the right.

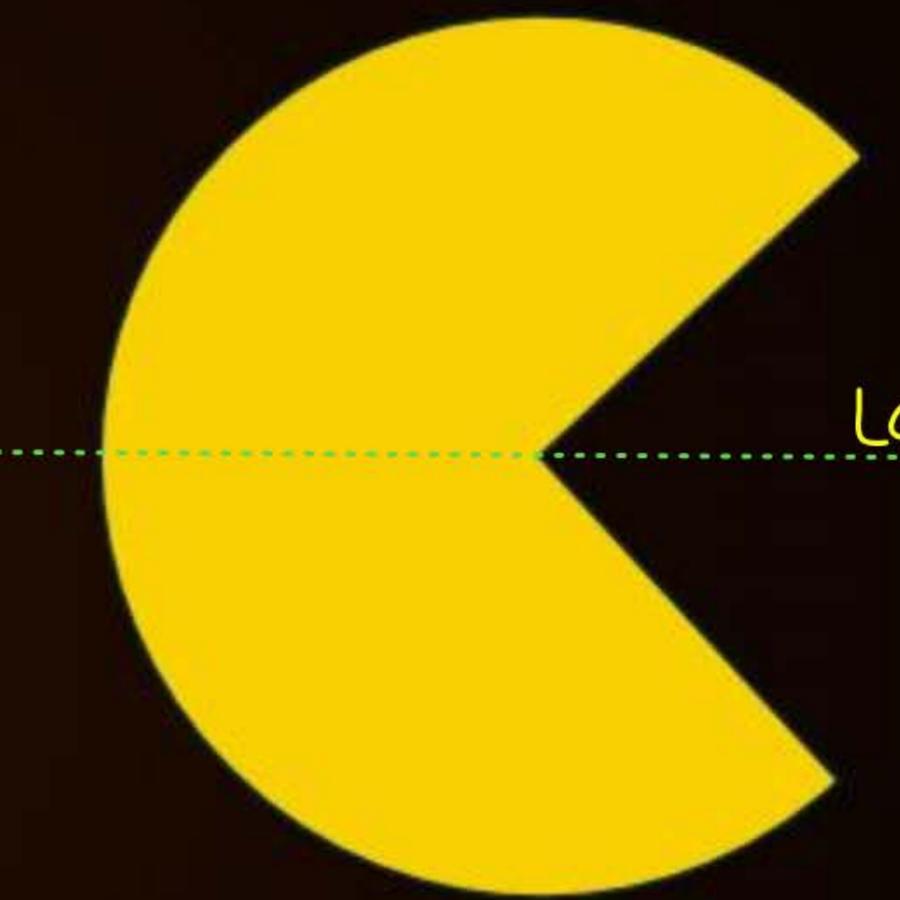


Los



Los

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Los

Linear mass density (λ)



mass per unit length

$$\lambda = \frac{m}{l} = \frac{dm}{dl}$$

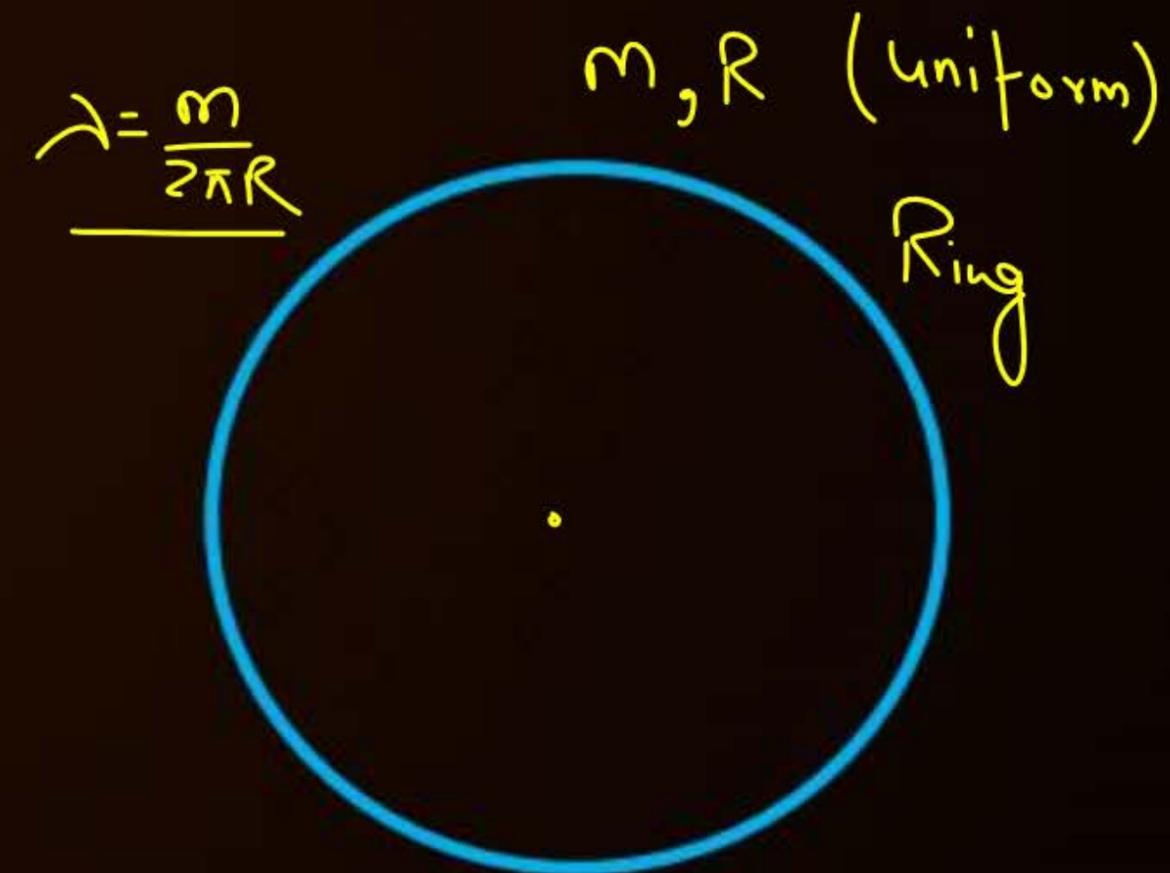
$$dm = \lambda dl$$

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m, l (uniform)



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



Surface mass density (σ)

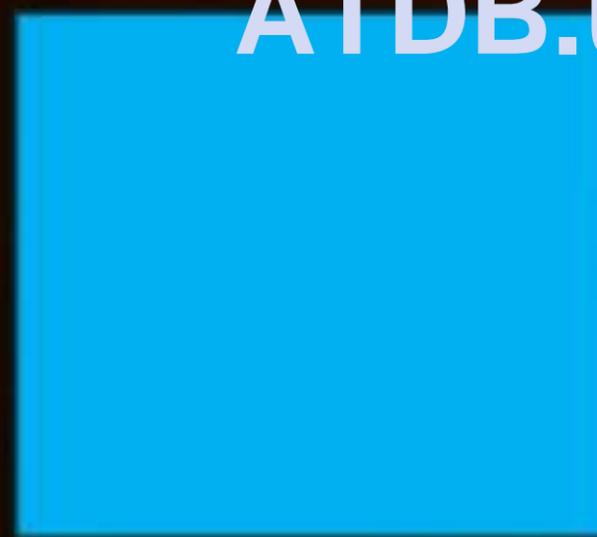


mass per unit area

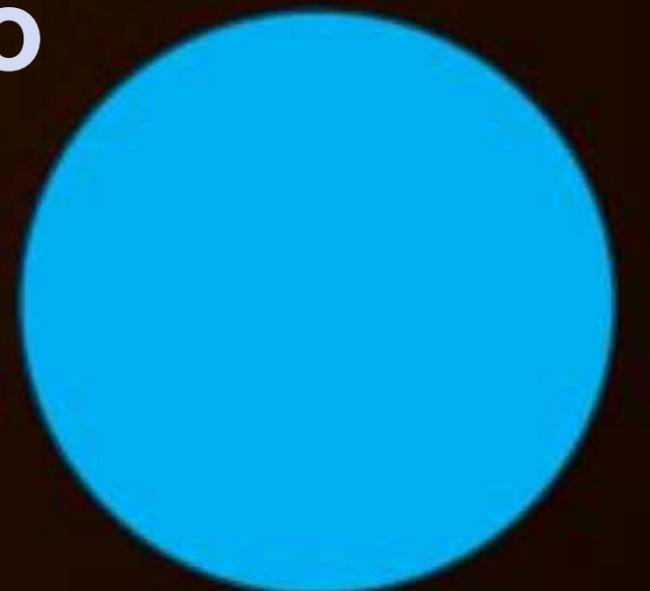
$$\sigma = \frac{\text{mass}}{\text{Area}} = \frac{dm}{dA}$$

$$dm = \sigma dA$$

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Square



disc



triangle

Volume mass density (ρ)



mass per unit volume

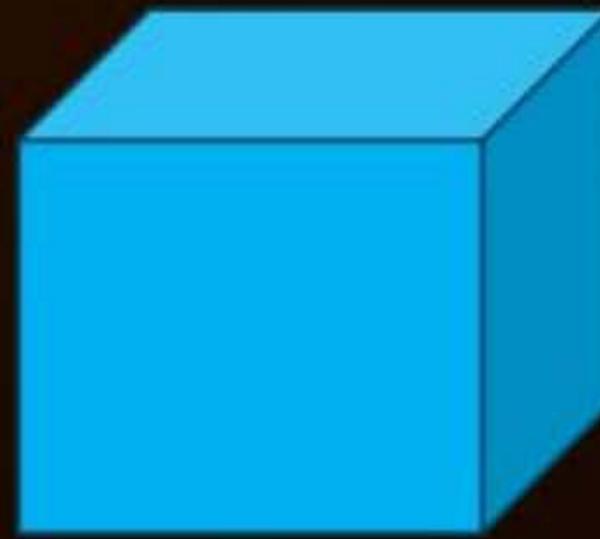
$$\rho = \frac{m}{V} = \frac{dm}{dV}$$

$$dm = \rho \cdot dV$$

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Cylinder



Cube



Sphere

Question - 6



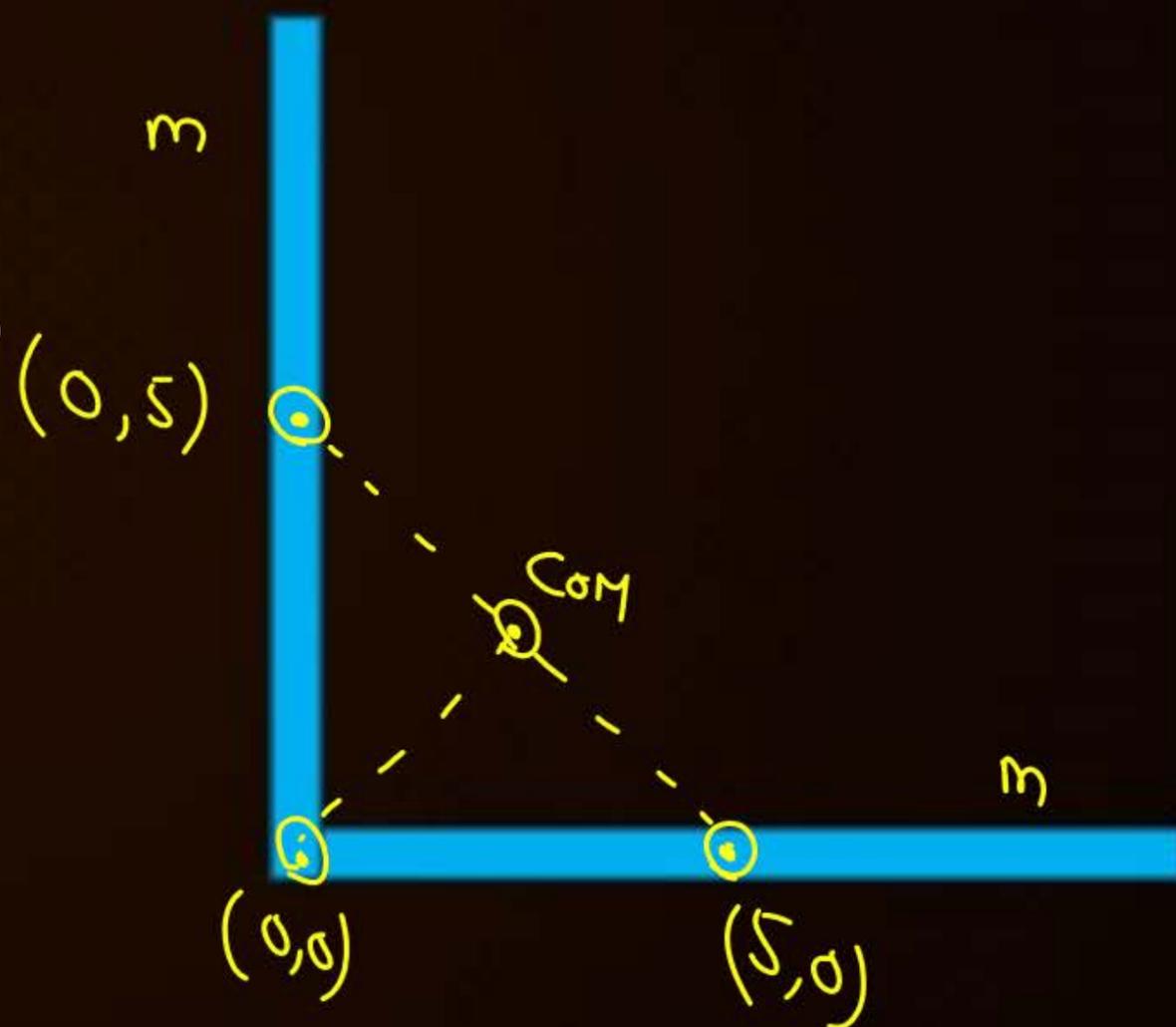
Two identical rods of length 10m are attached as shown find distance of com of system from joint of both rods

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

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

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

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



Question - 1



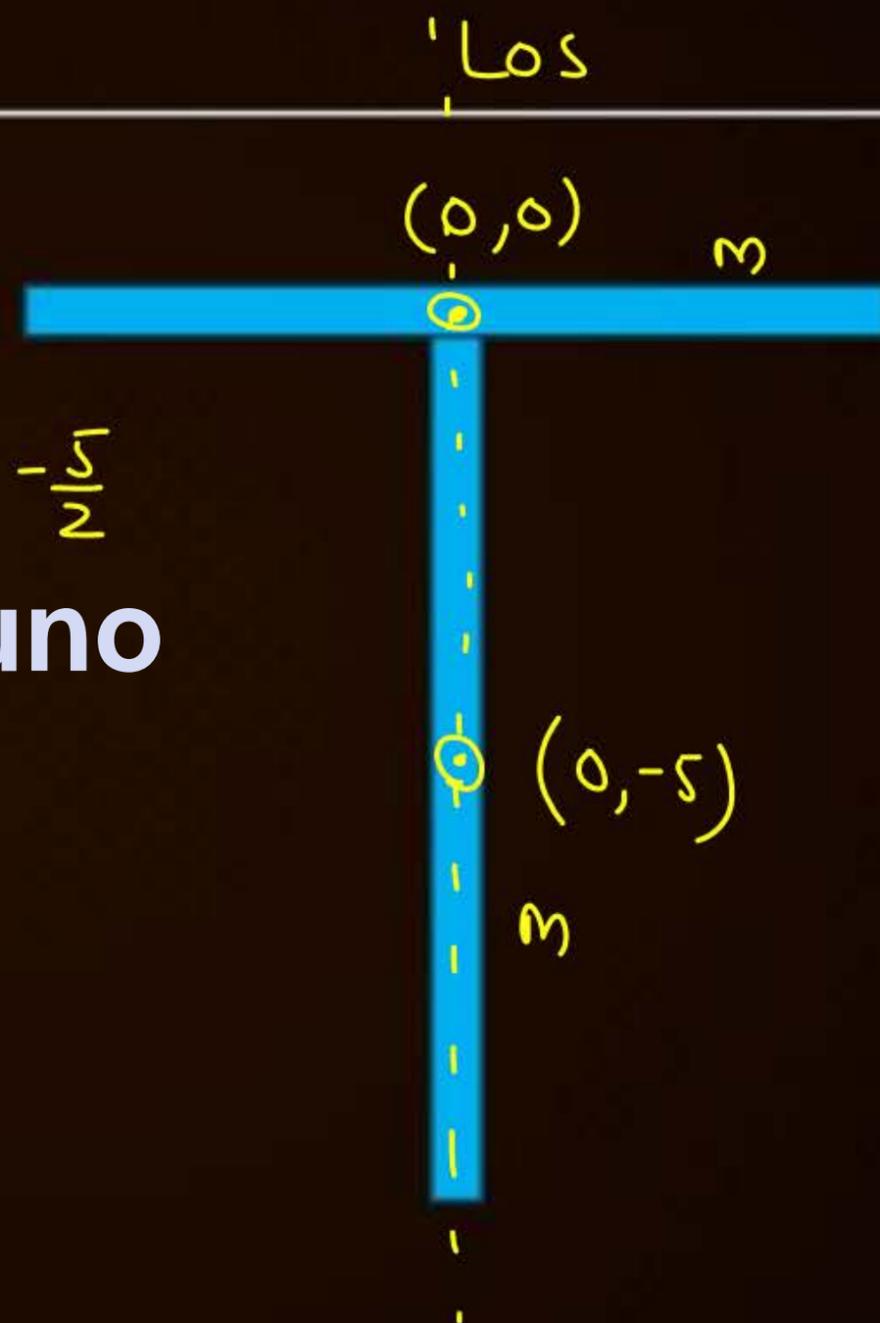
Two identical rods of length 10m are attached as shown find distance of com of system from joint of both rods

- (A) 5 m
 (B) 2.5 m
 (C) 10 m
 (D) $\frac{5}{4}$ m

$$x_{cm} = 0$$

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

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Question - 0



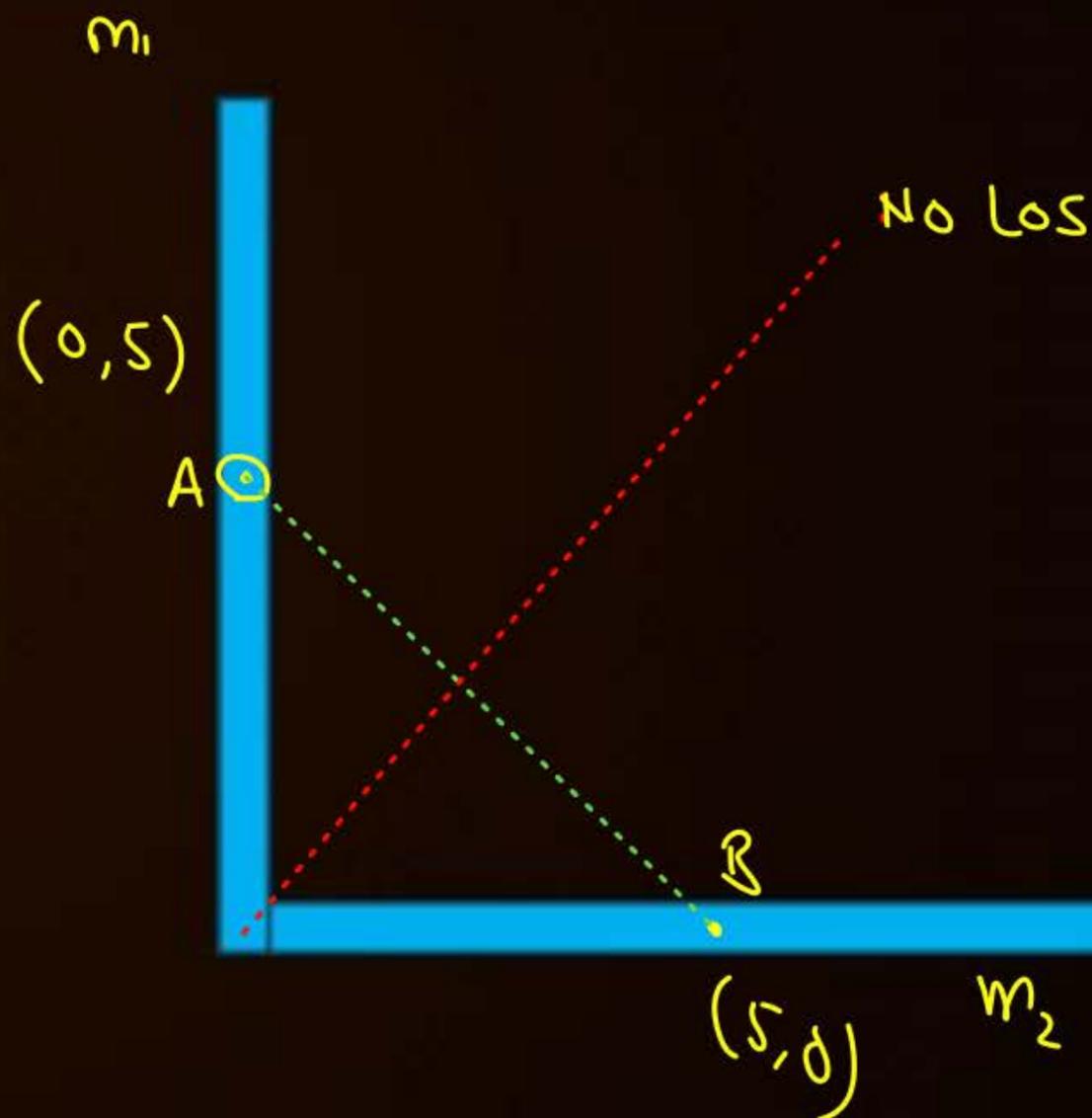
Two rods of length 10m are attached as shown find Equation of curve at which com of system lies, take origin at joint of both rods and X and y axis along rods (remember both rods may have different masses)

COM must lie on line Segment AB

Eqⁿ of line $y = mx + c$

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

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



Question - 9

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)
✓

(-1, 6)
✓ X

m_1

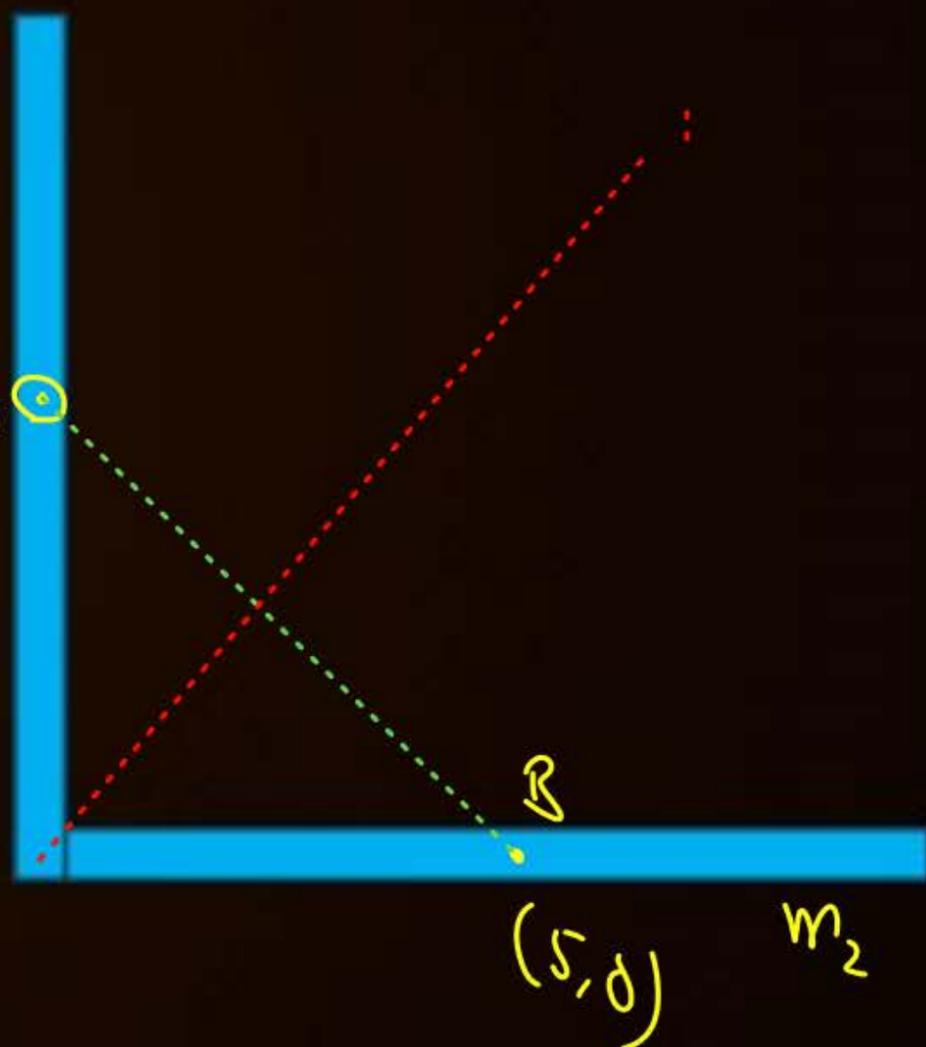
(0, 5)

A

B

(5, 0)

m_2



Question 10

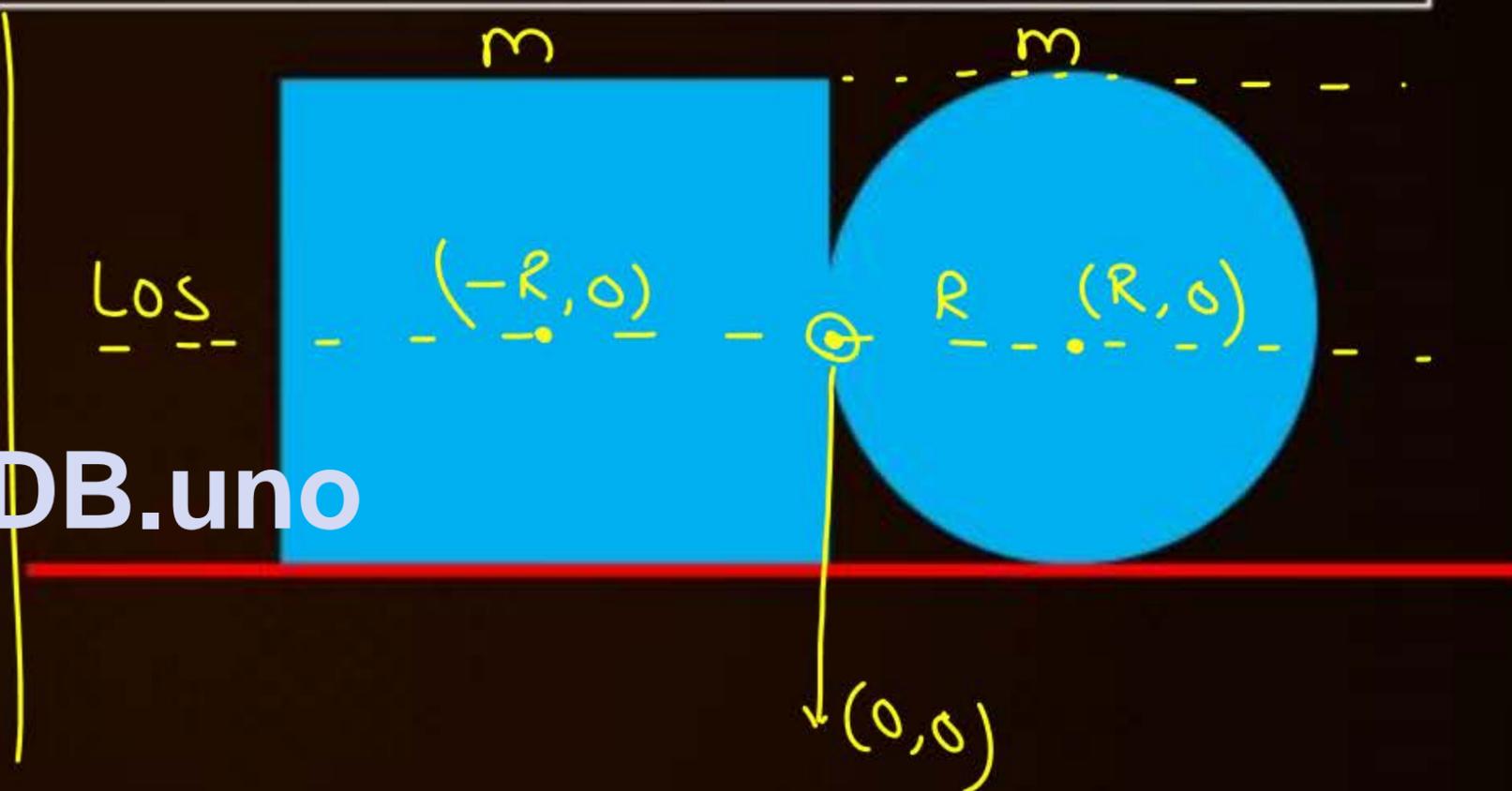


A square of side $2R$ and a disc of radius R are kept in contact as shown. Find distance of COM of system from contact point. Given both objects have same mass

$$y_{cm} = 0$$

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

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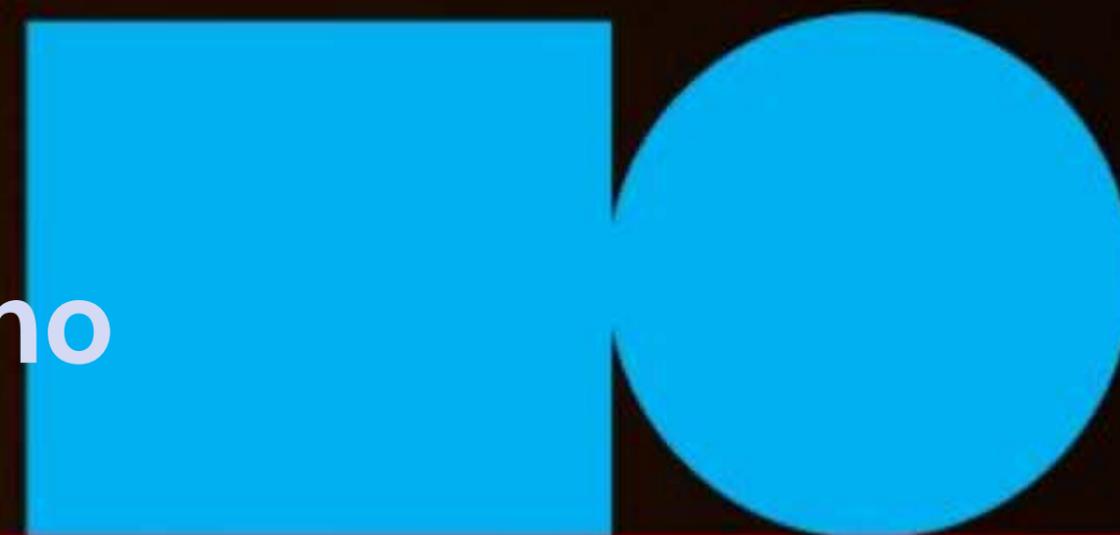


Question

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)



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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

A diagram showing a horizontal rod of length $2R$ and mass $4m$ in contact with a disc of radius R and mass m . The rod is positioned such that its right end is at the center of the disc. The contact point is the point where the rod's end touches the disc's surface.

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Question - 15

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

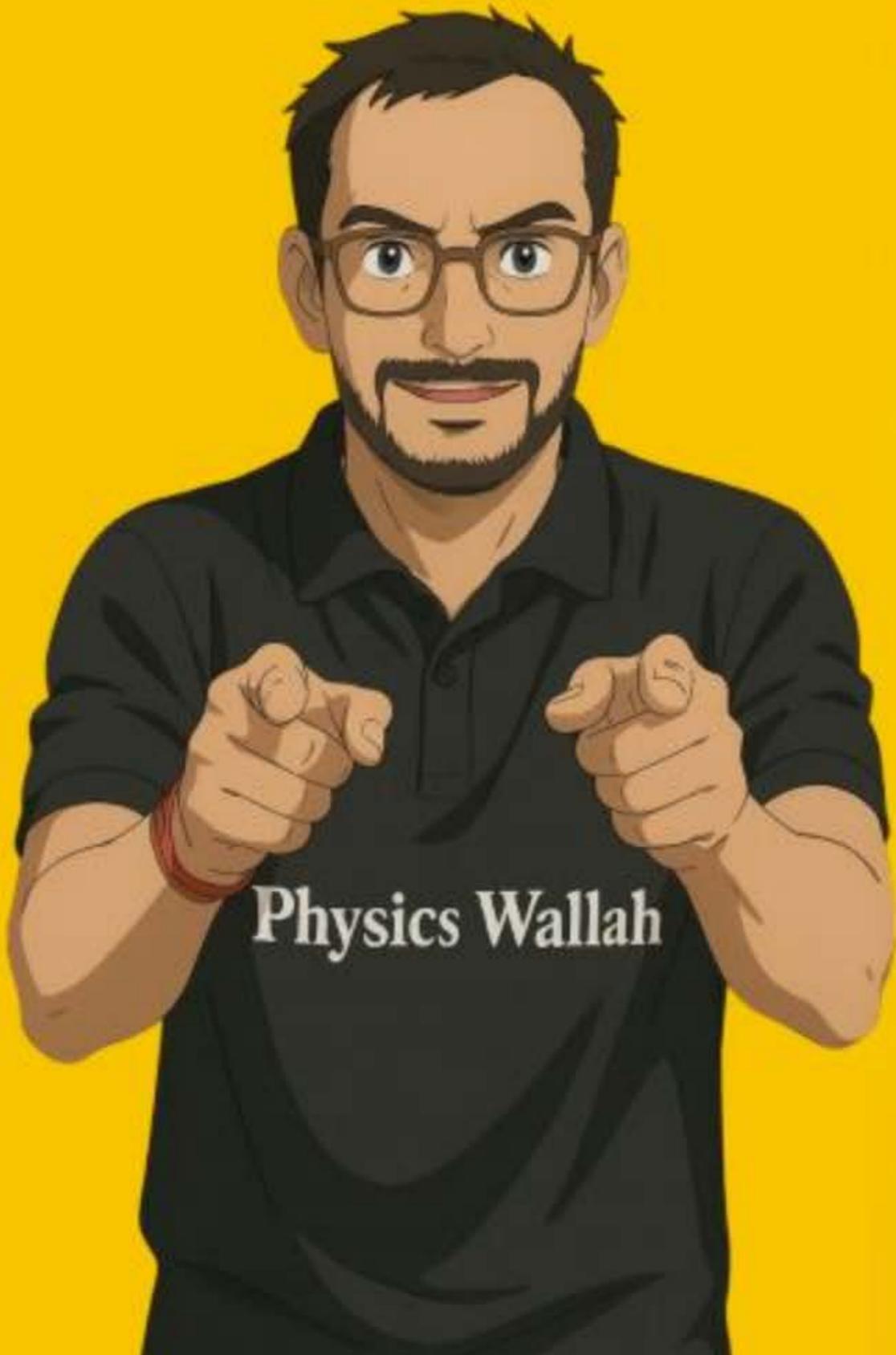
$$\text{mass} = \lambda(\text{length})$$

$$dm = \lambda dl$$

$$X_{cm} = \frac{\int X dm}{\int dm}$$



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THANK YOU
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BACCCHA
PARTY