Nishant Jindal

KINEMATICS

(1). Concept of distance & displacement :→

(actual)

⇒ **Distance** :- It is the ^ path length of the particle.

⇒ **Displacement** :→ [It is the vector joining initial position. to the final position of the particle.]

or, " Change in position vector "→ [Position vector must be w.r.t Origin].

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[Change in an interval]

By Δ-Law of vector addition :→

$$\vec{r}_i + \Delta\vec{r} = \vec{r}_f$$

$$\boxed{\Delta\vec{r} = [\vec{r}_f - \vec{r}_i]}$$

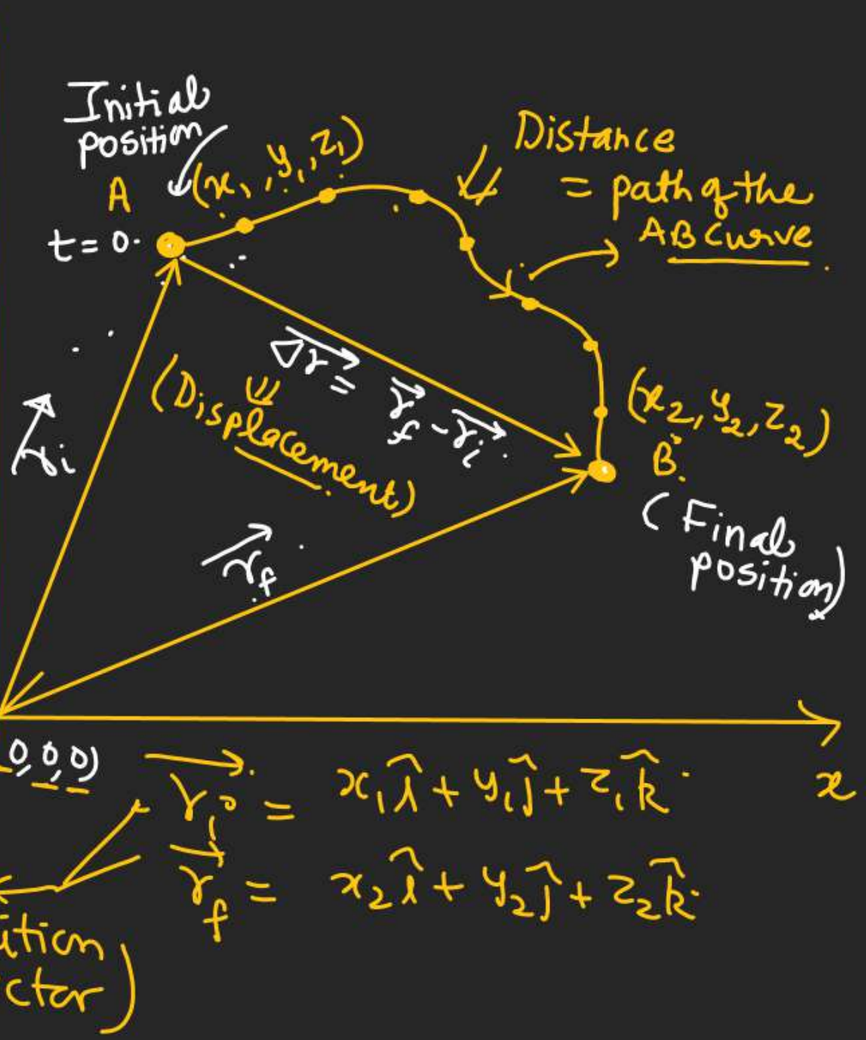
[Displacement vector] — Change in position vector.

$$\Delta\vec{r} = \vec{r}_{AB}$$

Displacement Vector.

$\vec{r}_i$ = Position vector

$\vec{r}_f$ = final position vector



$$\vec{r}_{AB} = (\text{Displacement vector})$$

$$= (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$$

$$\left[|\vec{r}_{AB}| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2} \right]$$

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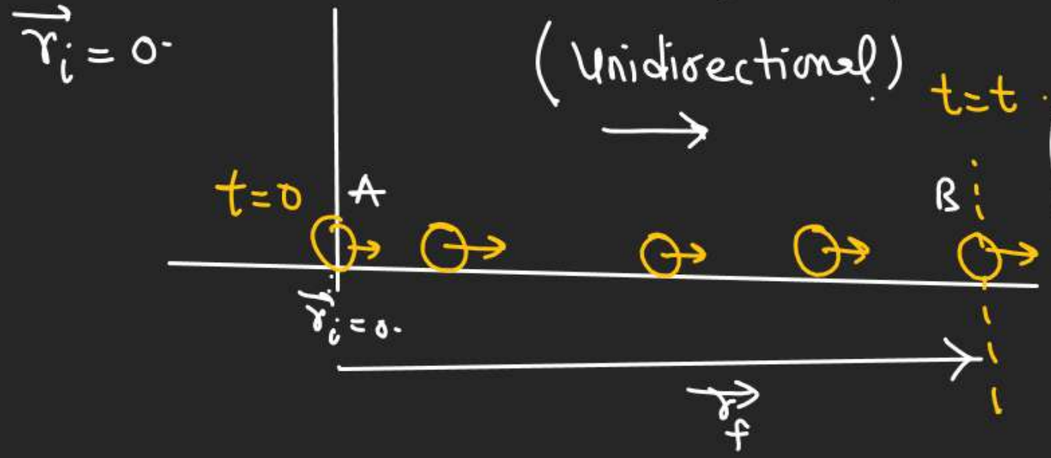
(Q) ⇒ Distance $\geq$ |Displacement|.

⇒ Distance is always +ve' it is a Scalar quantity but displacement can be (+ve) or (-ve) and it is a Vector quantity.

⇒ [Distance = Displacement]

⇒ When motion of the particle is a Straight line and unidirectional



$\vec{\Delta r} = \vec{r}_f - \vec{r}_i$

$\vec{\Delta r} = \vec{r}_f$

Actual path length = AB = $|\vec{r}_f|$

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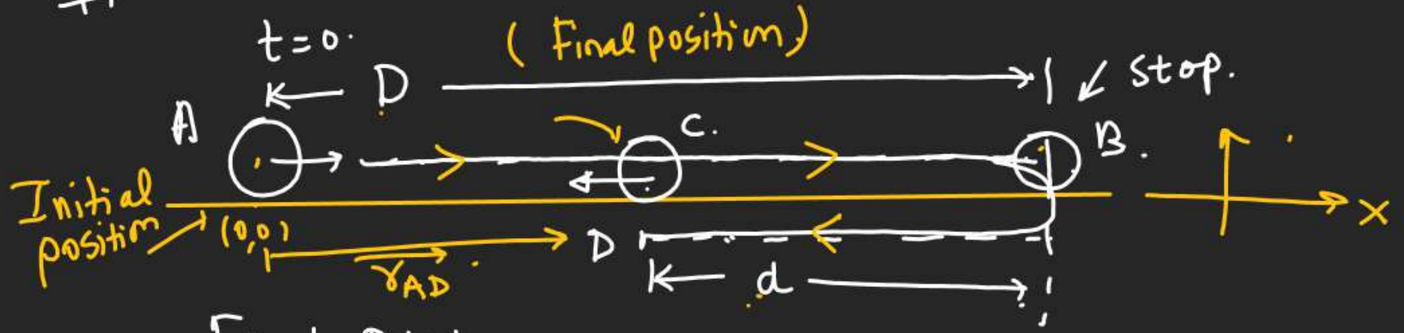
#



⇒ Find Distance and displacment for the motion ACBD

Displacement ⇒ $\vec{r}_{AD} = (D-d)\hat{i}$

$|\vec{r}_{AD}| = (D-d)$ m

Distance = Actual path length of ACBD = $(D+d)$ m.

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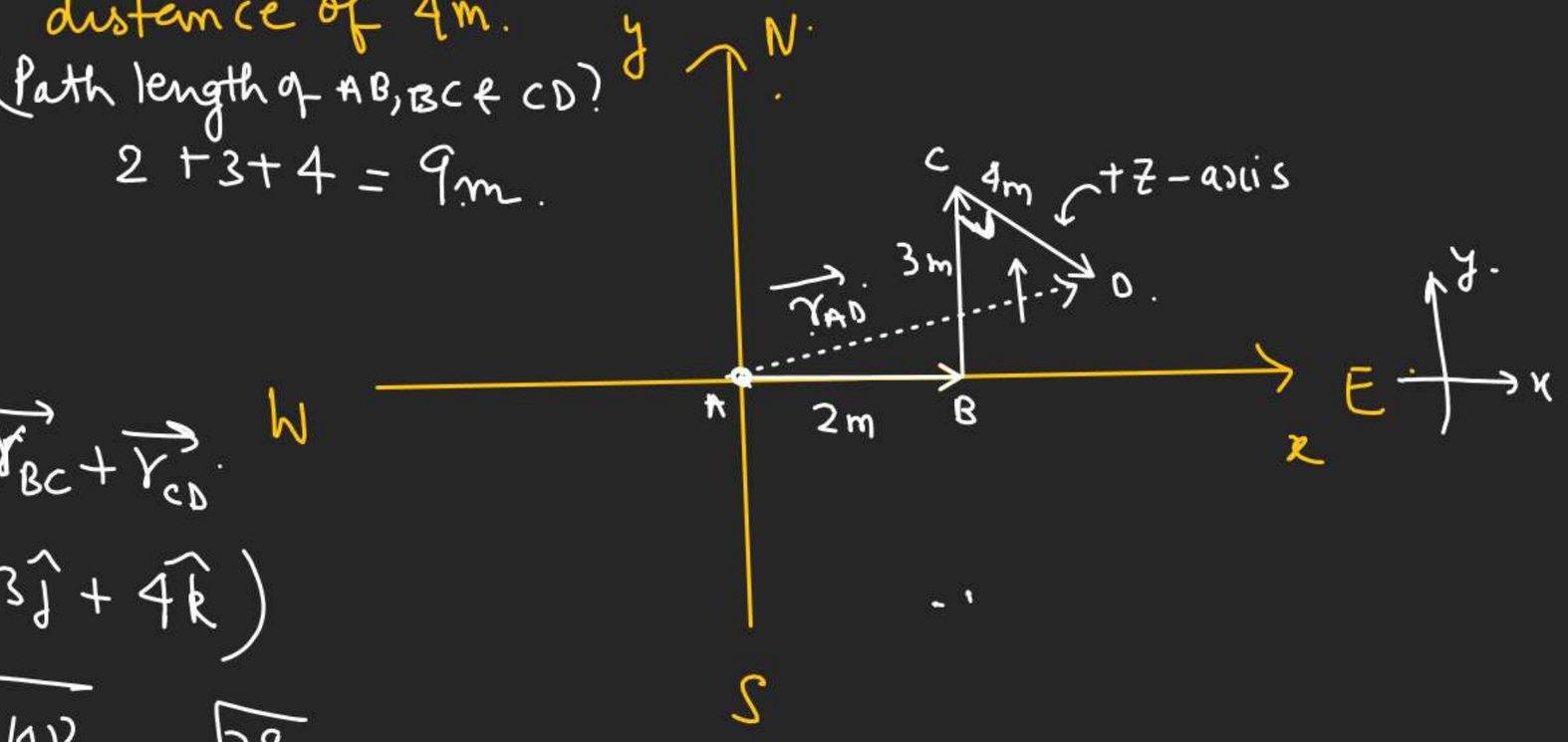
A bird starts flying in east direction and cover a distance of 2m after that it turns towards north and cover a distance of 3m. and finally move perpendicularly outward and cover a distance of 4m.

[∴ Find 1) distance = (Path length of AB, BC & CD)

2) displacement = $2+3+4 = 9\,m$.



Displacement ⇒

$$\vec{r}_{AD} = \vec{r}_{AB} + \vec{r}_{BC} + \vec{r}_{CD}$$

$$= (2\hat{i} + 3\hat{j} + 4\hat{k})$$

$$|\vec{r}_{AD}| = \sqrt{(2)^2+(3)^2+(4)^2} = \sqrt{29}\,m$$

∴

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⇒ "Displacement is always zero if initial and final position vector is same."

possible when particle is moving in a close path.

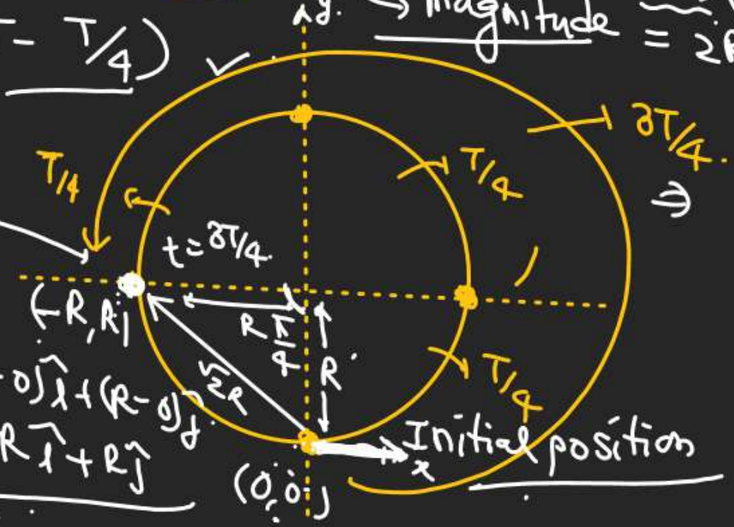
Find Distance and displacement. [T → To Cover one complete rotation.]

a) for $t=0$ to $t=T$ → Distance $= 2\pi R$, Displacement $= 0$ $\quad T = \left[\frac{2\pi R}{v}\right]$

b) for $t=0$, to $t = T/2$ → Distance = path length ACB $= (\pi R)$, Displacement $= (2R)\hat{j}$, magnitude $= 2R$ m

c) for $t=0$, to $t = \frac{3T}{4}$

$t = \frac{3T}{4} = \left(T - \frac{T}{4}\right)$



Magnitude of displacement = $\sqrt{2}R$

final position

Displacement vector $= (-R-0)\hat{i} + (R-0)\hat{j}$

$= -R\hat{i} + R\hat{j}$

⇒ Distance = .

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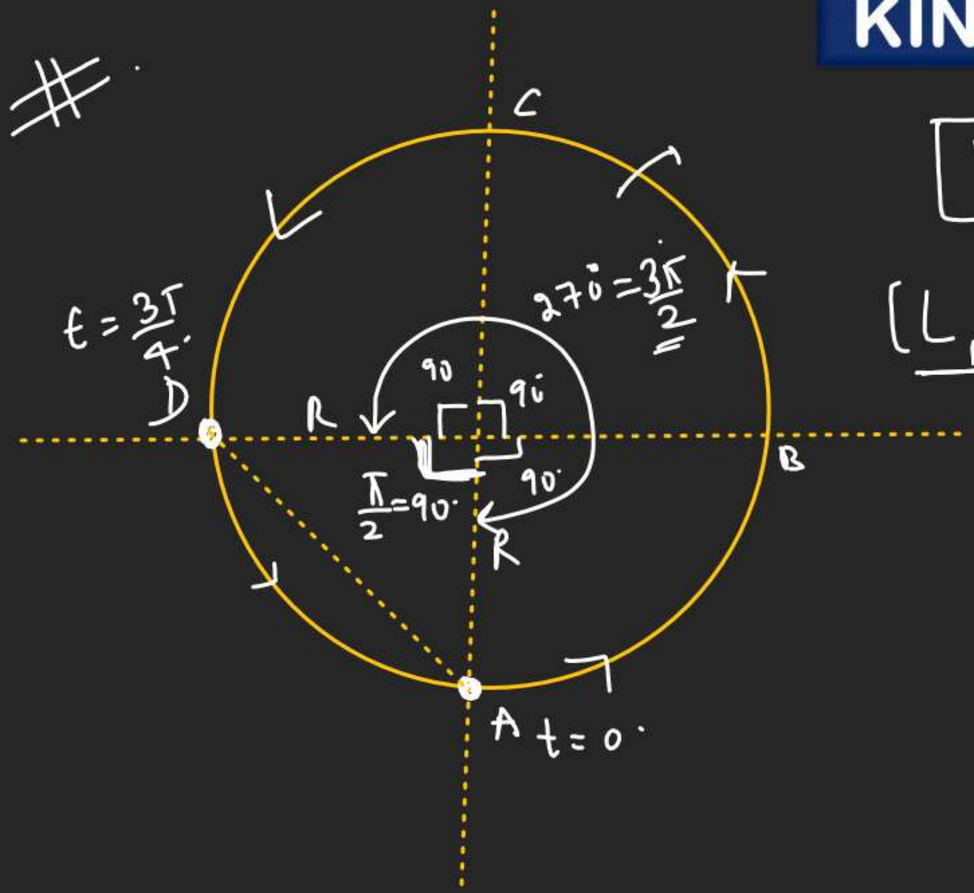

$L = R\theta$

↓ radian.

$[L_{ABCD}]$ ↳ major arc $= R \times \frac{3\pi}{2}$

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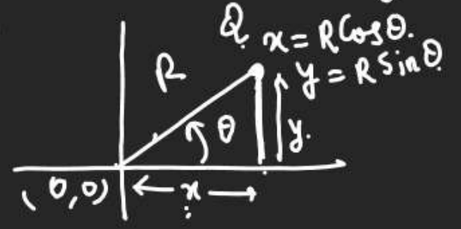
Distance and displacement at an angular displacement 'θ' in Uniform Circular motion ($v = c$)

$$\vec{r}_{PQ} = (R\cos\theta - R)\hat{i} + (R\sin\theta)\hat{j}$$

Displacement vector



$$|\vec{r}_{PQ}| = \sqrt{R^2(\cos\theta - 1)^2 + R^2\sin^2\theta}$$

$$= R\sqrt{\cos^2\theta + 1 - 2\cos\theta + \sin^2\theta}$$

$$= R\sqrt{2 - 2\cos\theta}$$

$$|\vec{r}_{PQ}| = R\sqrt{2(1 - \cos\theta)} = R\sqrt{2\left[1 - \left(1 - 2\sin^2\frac{\theta}{2}\right)\right]}$$

$$= R\sqrt{4\sin^2\frac{\theta}{2}} = \left[2R\sin\frac{\theta}{2}\right]$$

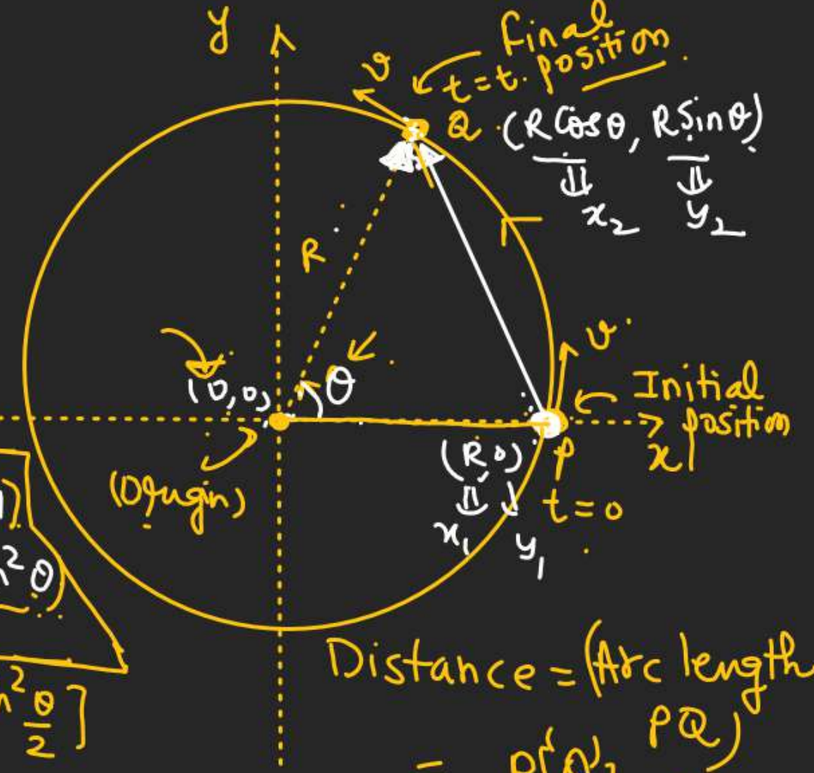
$$PQ = 2R\sin\frac{\theta}{2}$$

**

$$\cos 2\theta = (2\cos^2\theta - 1)$$

or $= (1 - 2\sin^2\theta)$

$$\cos\theta = \left(1 - 2\sin^2\frac{\theta}{2}\right)$$



Distance = (Arc length PQ)

$$= R[\theta]_{\text{radian}}$$

$$= R\left(\frac{\pi}{180} \times \theta\right)$$

if θ in degree

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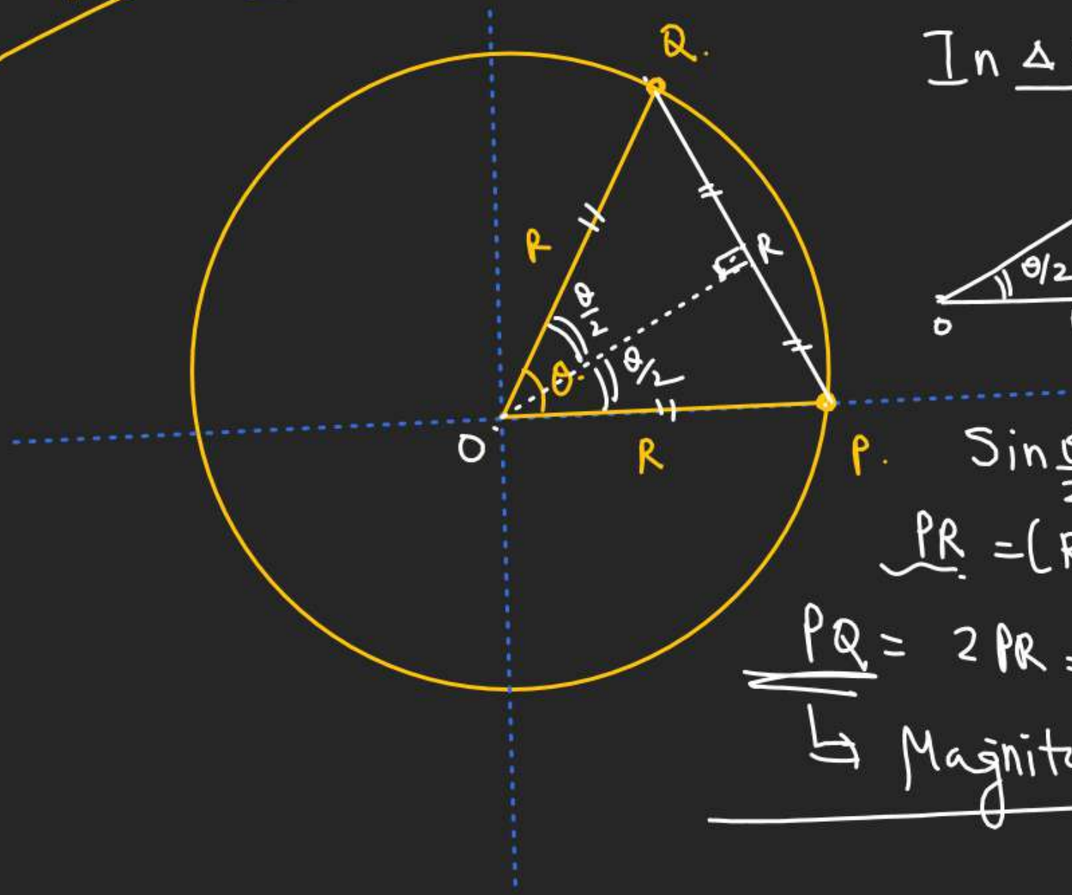
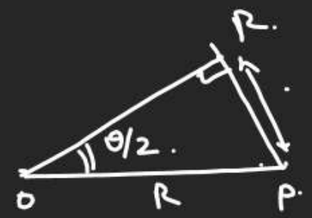
Another Method

For displacement



In $\triangle OPR$



$$\sin\frac{\theta}{2} = \frac{PR}{R}$$

$$PR = [R \sin\frac{\theta}{2}]$$

$$PQ = 2PR = \left[2R\sin\frac{\theta}{2}\right]$$

↳ Magnitude of displacement

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Q. A particle moves in a semicircular path of radius R from O to A (Fig.) Then it moves parallel to z – axis covering a distance R upto B. Finally it moves along BC parallel to y – axis through a distance 2 R. Find the ratio of D/s.