Physicsaholics

DPP – 2 (Circular Motion)

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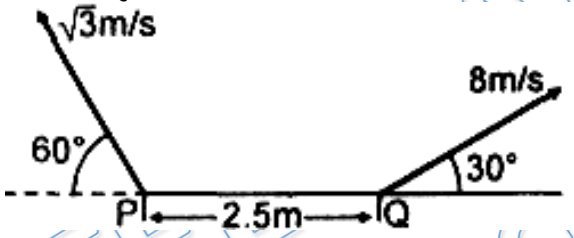
Q 1. Starting from rest, a particle rotates in a circle of radius R = 2m with an angular acceleration $\alpha = \frac{\pi}{4}\ rad/s^2$. The magnitude of average velocity of the particle over the time it rotates quarter circle is:

(a) $2\ m/s$ (b) $1\ m/s$

(c) $\sqrt{2}\ m/s$ (d) $2\sqrt{2}\ m/s$

Q 2. Two particles P and Q are moving as shown in the figure. At this moment of time the angular speed of P w.r.t. Q is:



(a) 1 rad/s (b) 2 rad/s

(c) 5 rad/s (d) 4 rad/s

Q 3. A ball is projected with $20\sqrt{2}$ m/s at angle 45° with horizontal. The angular velocity of the particle at highest point of its journey about point of projection is:

(a) 0.1 rad/s (b) 0.2 rad/s

(c) 0.3 rad/s (d) 0.4 rad/s

Q 4. The magnitude of displacement of a particle moving in a circle of radius a with constant angular speed ω varies with time t as: The tangential and angular acceleration of a particle are 10 m/sec^2 and 5 rad/sec^2 respectively it will be at a distance from the axis of rotation -

(a) 50 m (b) ½ m

(c) 1 m (d) 2 m

Q 5. A particle moves in a circle of radius 25 cm at angular speed 4π rad/s. The acceleration of particle in m/s^2 is -

(a) π^2 (b) $8\pi^2$

(c) $4\pi^2$ (d) $2\pi^2$

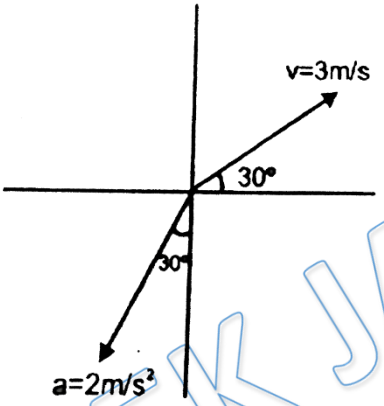
Q 6. In a circular motion of a particle the tangential acceleration of the particle is given by $a_t = 2t\ m/s^2$. The radius of the circle described is 4m. The particle is initially at rest. Time after which total acceleration of the particle makes 45^0 with radial acceleration is:

(a) 1 sec (b) 2 sec

(c) 4 sec (d) 8 sec

Q 7. A particle moves along a circle if radius $\frac{20}{\pi}$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begun the tangential acceleration is:
(a) 40 m/s^2 (b) 640 m/s^2
(c) 160 m/s^2 (d) 80 m/s^2

Q 8. Initial velocity and acceleration of a particles are as shown in the figure. Acceleration vector of particle remain constant. Then radius of curvature of path of particle :



(a) is 9 m initially (b) is $\frac{9}{2}$ m initially
(c) is $\frac{9}{\sqrt{3}}$ m initially (d) is $\frac{9}{8}$ m initially

Q 9. A particle is moving in an isolated $x-y$ plane. At an instant, the particle has velocity $(4\hat{\imath}+4\hat{\jmath})$ m/s and acceleration $(3\hat{\imath}+5\hat{\jmath})\ m/s^2$. At that instant what will be the radius of curvature of its path?
(a) 16 m (b) 15 m
(c) $16\sqrt{2}$m (d) none of these

Q 10. A disc rotates about its axis with a constant angular acceleration of 4 rad/s^2. Find the radial and tangential acceleration of a particle at a distance of 1 cm from the axis at the end of the first second after the disc starts rotating:
(a) 0.16 m/s^2, 0.4 m/s^2 (b) 1.6 m/s^2, 0.04 m/s^2
(c) 1.6 m/s^2, 0.4 m/s^2 (d) 0.16 m/s^2, 0.04 m/s^2

Answer Key

Q.1 c	**Q.2 a**	**Q.3 b**	**Q.4 d**	**Q.5 c**
Q.6 b	**Q.7 a**	**Q.8 a**	**Q.9 c**	**Q.10 d**

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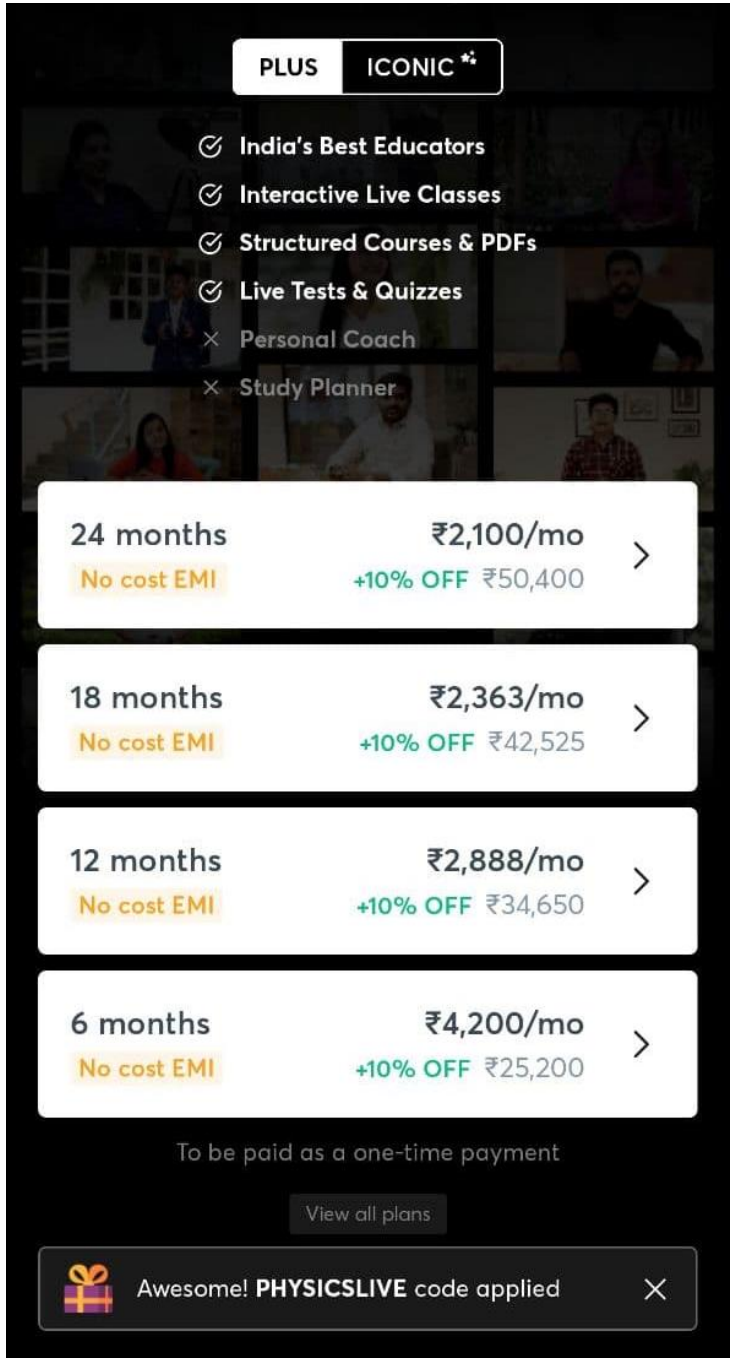
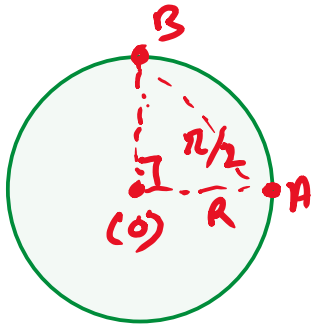


Written Solution

DPP-2 (Relation between linear and angular quantities, Tangential and Radial acceleration and Radius of curvature)

By Physicsaholics Team

Solution: 1



$R = 2\ m$

$V_{avg} = \frac{disp.}{time}$

$disp. = \sqrt{2}R$

$= \pi\sqrt{2} \times 2 = 2\pi\sqrt{2}\ m$

$V_{avg} = \frac{2\pi\sqrt{2}}{2}$

$\boxed{V_{avg} = \pi\sqrt{2}\ m/s}$

time

$t = ?$

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

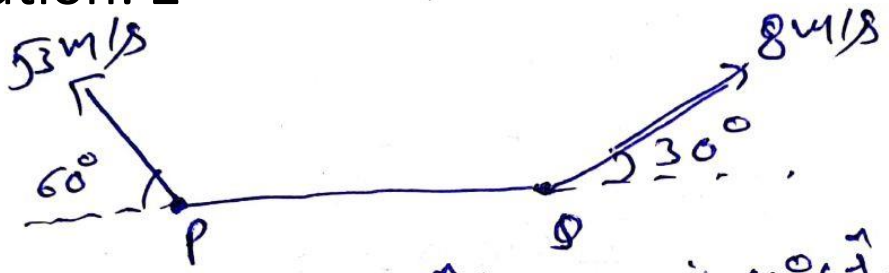
$\frac{\pi}{2} = 0 + \frac{1}{2}(\frac{\pi}{4})t^2$

$t^2 = 4$

$\boxed{t = 2\ sec}$

Ans. c

Solution: 2



$$\vec{V}_P = \sqrt{3}\cos 60^\circ(-\hat{i}) + \sqrt{3}\sin 60^\circ(\hat{j})$$

$$\vec{V}_P = -\frac{\sqrt{3}}{2}\hat{i} + \frac{3}{2}\hat{j} \quad -(1)$$

$$\vec{V}_Q = 8\cos 30\,\hat{i} + 8\sin 30\,\hat{j}$$

$$\vec{V}_Q = 4\sqrt{3}\,\hat{i} + 4\hat{j} \quad -(2)$$

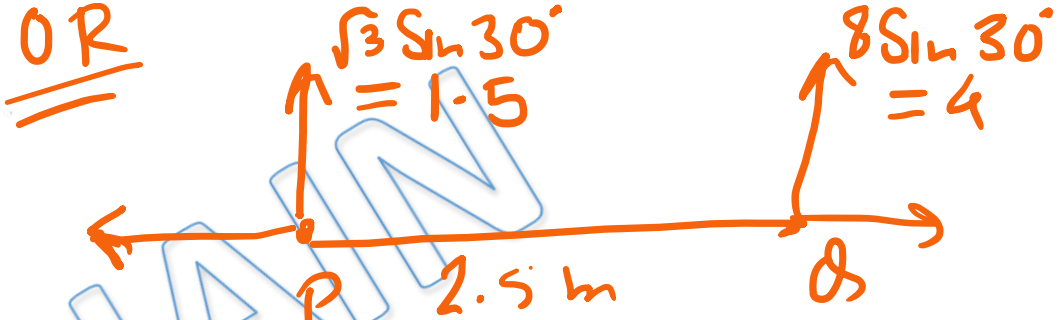
$$\vec{V}_{P/Q} = \vec{V}_P - \vec{V}_Q = -\left(\frac{\sqrt{3}}{2} + 4\sqrt{3}\right)\hat{i} + \left(\frac{3}{2} - 4\right)\hat{j}$$

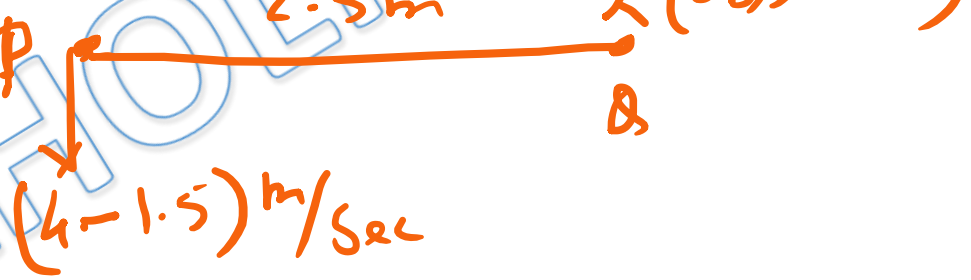
$$\vec{V}_{P/Q} = -\frac{9}{2}\sqrt{3}\,\hat{i} - \frac{5}{2}\hat{j}$$

$$\omega = \frac{V_\perp}{r} = \frac{\sqrt{12}}{(\sqrt{12})}$$

$$\boxed{\omega = 1 \text{ rad/sec}}$$

OR

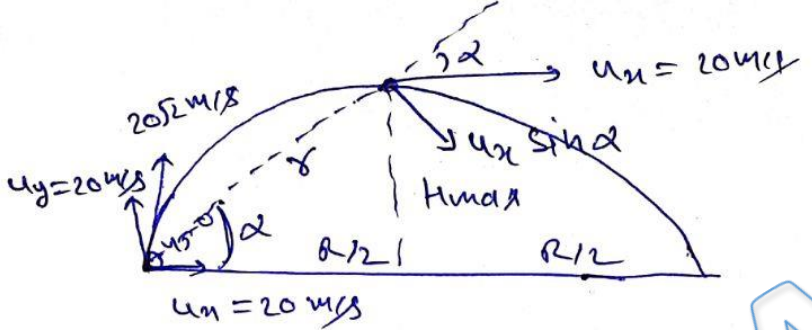




$$\omega_{P,Q} = \frac{4 - 1.5}{2.5} = 1 \text{ rad/Sec}$$

Ans. a

Solution: 3



$$H_{max} = \frac{u_y^2}{2g} = \frac{(20)^2}{2\times 10} = 20\,m.$$

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{(20\sqrt{2})^2 \sin 90^\circ}{10} = 80\,m.$$

$$\tan\alpha = \frac{H_{max}}{(R/2)} = \frac{20}{(\frac{80}{2})} = \frac{20}{40} = \frac{1}{2}$$

$$\sin\alpha = \frac{1}{\sqrt{5}}$$

$$r = \sqrt{(\tfrac{R}{2})^2 + H_{max}^2}$$

$$r = \sqrt{40^2 + 20^2} = 20\sqrt{5}\ m.$$

$$\omega = \frac{v_1}{r} = \frac{u_x \sin\alpha}{r}$$

$$\omega = \frac{(20)(\frac{1}{\sqrt{5}})}{20\sqrt{5}} = \frac{1}{\sqrt{5}\times\sqrt{5}}$$

$$\omega = \frac{1}{5}$$

$$\boxed{\omega = 0.2\ rad/sec}$$

Ans. b

Solution: 4

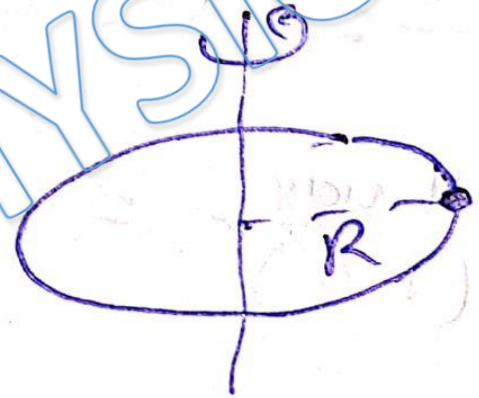
$$a = 10 \text{ m/s}^2$$

$$\alpha = 5 \text{ rad/s}^2$$

$$a = \alpha R$$

$$10 = 5R$$

$$\boxed{R = 2 \text{ m}}$$



Ans. d

Solution: 5

$\omega = 4\pi$ rad/sec

$V = R\omega = 25 \times 10^{-2} \times 4\pi$

$V = \pi$ m/s

Now $a = \frac{V^2}{R}$

$a = \frac{\pi^2}{25 \times 10^{-2}}$

$\boxed{a = 4\pi^2 \text{ m/s}^2}$

Ans. c

Solution: 6

$a_t = 2t \ m/s^2$

$\frac{dv}{dt} = 2t$

$\int_0^v dv = \int_0^t 2t\,dt \Rightarrow v - 0 = \frac{2t^2}{2}$

$v = t^2 \ m/s$ — (1)

radial acceleration $= a_r = \frac{v^2}{R} = \frac{(t^2)^2}{4}$

$a_r = \frac{t^4}{4} \ m/s^2$

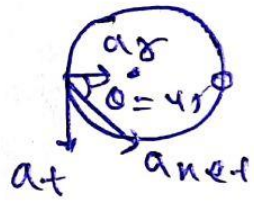
Tangential acceleration $= 2t$

for $a_r = a_t$

$\frac{t^4}{4} = 2t$

$t^3 = 8$

$\boxed{t = 2 \text{ sec}}$

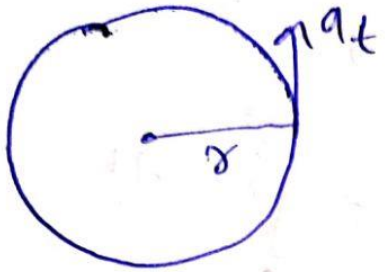


$\tan\theta = \frac{a_t}{a_r}$

$\Rightarrow a_t = a_r$

Ans. b

Solution: 7



$a_t = ?$

$r = \frac{20}{\pi}$

$u = 0 \Rightarrow \omega_0 = 0$

$v = 80\ m/s \Rightarrow \omega = \frac{80}{\left(\frac{20}{\pi}\right)} = 4\pi$

$\omega = 4\pi\ rad/sec$

$\omega^2 - \omega_0^2 = 2\alpha\theta$

$\theta = 2\pi \times 2 = 4\pi$ in 2 revolution

$(4\pi)^2 - 0 = 2\alpha(4\pi)$

$\alpha = 2\pi\ rad/sec^2$

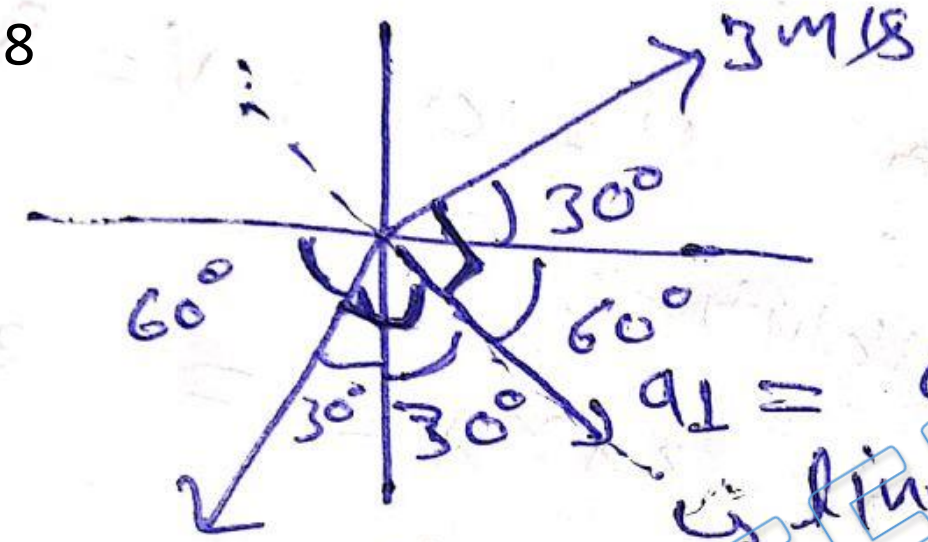
$a_t = \alpha R$

$a_t = 2\pi \times \frac{20}{\pi}$

$\boxed{a_t = 40\ m/s^2}$

Ans. a

Solution: 8



$a_1 = a\cos 60°$

a_1 line is ⊥ to velocity vector

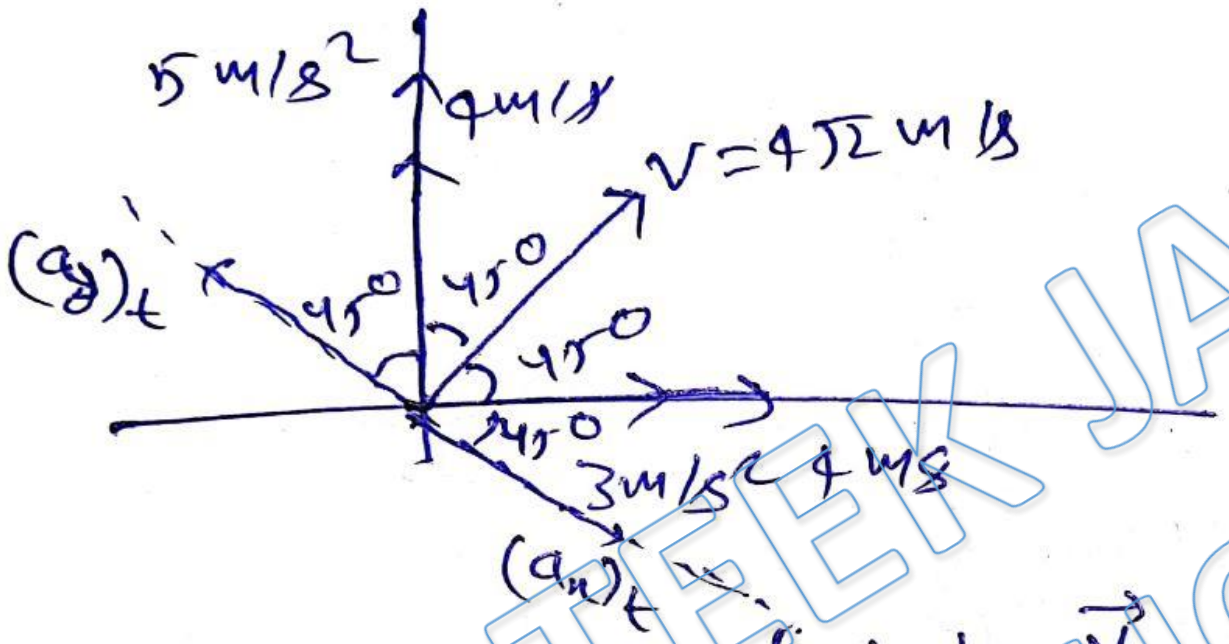
radius of curvature — $R = \frac{v^2}{a_1}$

$R = \frac{(3)^2}{(2\cos 60°)} = \frac{9}{2 \times \frac{1}{2}} = 9\ m$

$$\boxed{R = 9\ m}$$

Ans. a

Solution: 9



$\perp$ to $\vec{V}$

$$a_\perp = 5\cos 45^\circ - 3\cos 45^\circ = 2\cos 45^\circ$$

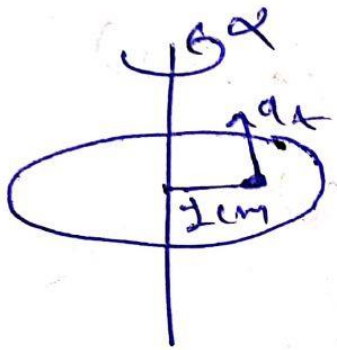
$$a_\perp = \sqrt{2}\ m/s^2$$

$$R.O.C \Rightarrow R = \frac{V^2}{a_\perp} = \frac{(4\sqrt{2})^2}{\sqrt{2}} = \frac{32}{\sqrt{2}}$$

$$\boxed{R = 16\sqrt{2}\ m}$$

Ans. c

Solution: 10



Tangential acceleration:

$$a_t = \alpha R$$

$$a_t = 4 \times 1 \times 10^{-2}$$

$$\boxed{a_t = 0.04 \text{ m/s}^2}$$

Angular acceleration:

$$a_r = \frac{v^2}{r}$$

$$v = u + a_t t$$

$$v = 0 + 0.04 \times 1$$

$$v = 0.04 \text{ m/s}$$

$$a_r = \frac{(0.04)^2}{1 \times 10^{-2}} = \frac{16 \times 10^{-4}}{10^{-2}}$$

$$\boxed{a_r = 0.16 \text{ m/s}^2}$$

Ans. d

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