DPP – 2 (Circular Motion)

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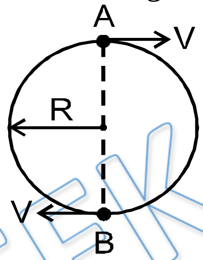
Q 1. Two bodies A and B are moving with same constant speed v in clockwise direction in a horizontal circle of radius R and are initially diametrically opposite as shown in figure. The particle B now achieves a tangential acceleration a m/s^2. Then :



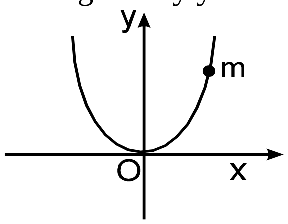
(a) they collide after time $\sqrt{\frac{\pi R}{a}}$

(b) they collide after time $2\sqrt{\frac{\pi R}{a}}$

(c) relative velocity just before collision is $\sqrt{\pi a R}$

(d) relative velocity just before collision is $\sqrt{2\pi a R}$

Q 2. A bead of mass m is located on a parabolic wire with its axis vertical and vertex at the origin as shown in figure and whose equation is $x^2 = 4ay$. The wire frame is fixed in vertical plane and the bead can slide on it without friction. The bead is released from the point y = 4a on the wire frame from rest. The tangential acceleration of the bead when it reaches the position given by y = a is :



(a) $\frac{g}{2}$ (b) $\frac{\sqrt{3}g}{2}$ (c) $\frac{g}{\sqrt{2}}$ (d) $\frac{g}{\sqrt{5}}$

Q 3. A heavy particle is projected from a point on the horizontal at an angle 45^0 with the horizontal with a speed of 20m/s. Then the radius of the curvature of its path at the instant of crossing the same horizontal is _______.

(a) $10\sqrt{2}$ (b) $40\sqrt{2}$ (c) $20\sqrt{2}$ (d) None of these

Q 4. A particle is fired from a point on the ground with speed u making an angle θ with the horizontal. Then:

(a) the radius of curvature of the projectile at the heighest point is $\frac{u^2 \cos^2 \theta}{g}$

(b) the radius of curvature of the projectile at the highest point is $\frac{u^2 \sin^2 \theta}{g}$

(c) at the point of projection tangential acceleration is g sin θ

(d) at the point of projection tangential acceleration is g cos θ

Q 5. An open merry – go – round rotates at an angular velocity. A person stands in it at a distance r from the rotational axis. It is raining and raindrops fall vertically with a velocity v. The person should hold an umbrella to protect himself with axis of umbrella tilted with vertical at angle:

(a) $tan^{-1}(v_0/r\omega)$ in the plane perpendicular to $\vec{r}$

(b) $tan^{-1}(r\omega/v_0)$ in the plane perpendicular to $\vec{r}$

(c) $tan^{-1}(r\omega/v_0)$ in the plane through $\vec{r}$

(d) None

Q 6. For a moving particle if a_r is radial acceleration and a_T is tangential acceleration, then match the motion of column II with conditions given in column I.

Column I	Column II
(A) $a_r = 0, a_T \neq 0$	(p) Non uniform circular
(B) $a_r \neq 0, a_T = 0$	(q) Uniform circular
(C) $a_r = 0, a_T = 0$	(r) accelerated translatory
(D) $a_r \neq 0, a_T \neq 0$	(s) uniform translatory

Q 7. A particle is projected with a velocity u at an angle θ with the horizontal. Find the radius of the curvature of the parabola traced out by the particle at the point where velocity makes an angle (θ/2) with the horizontal.

(a) $\frac{u^2 \cos^2 \theta}{2g \cos^3 \frac{\theta}{2}}$ (b) $\frac{2u^2 \cos^2 \theta}{g \cos^3 \frac{\theta}{2}}$

(c) $\frac{3u^2 \cos^2 \theta}{2g \cos^3 \frac{\theta}{2}}$ (d) $\frac{u^2 \cos^2 \theta}{g \cos^3 \frac{\theta}{2}}$

Comprehension (Q.8 to Q.10)

A horizontal rod is rotating about a vertical axis passing through its one end with constant angular velocity 1 rad/sec. An insect starts moving on it from axis with constant speed 1m/sec relative to rod.

Q 8. Speed of insect at t = 1 sec is

(a) 1m/sec (b) 2m/sec (c) $\sqrt{2}$ m/sec (d) 2 $\sqrt{2}$ m/sec

Q 9. Tangential acceleration of insect at t = 1 sec

(a) $\sqrt{2}$ m/sec^2 (b) $\frac{1}{\sqrt{2}}$ m/sec^2

(c) 1 m/sec^2 (d) 2 m/sec^2

Q 10. Direction of radial acceleration of insect at t = 1 is

(a) Along rod (b) perpendicular to rod
(c) At angle 45^0 with rod (d) None of these

Q 11. For a particle moving along circular path, the radial acceleration a_r is proportional to time t. If a_t is the tangential acceleration, then which of the following will be independent of time t?
(a) a_t (b) $a_r a_t$ (c) $\frac{a_r}{a_t}$ (d) $a_r(a_t)^2$

Q 12. A particle starts travelling on a circle with constant tangential acceleration. The angle between velocity vector and acceleration vector, at the moment when particle completes half the circular track, is
(a) $\tan^{-1}(2\pi)$ (b) $\tan^{-1}(\pi)$
(c) $\tan^{-1}(3\pi)$ (d) zero

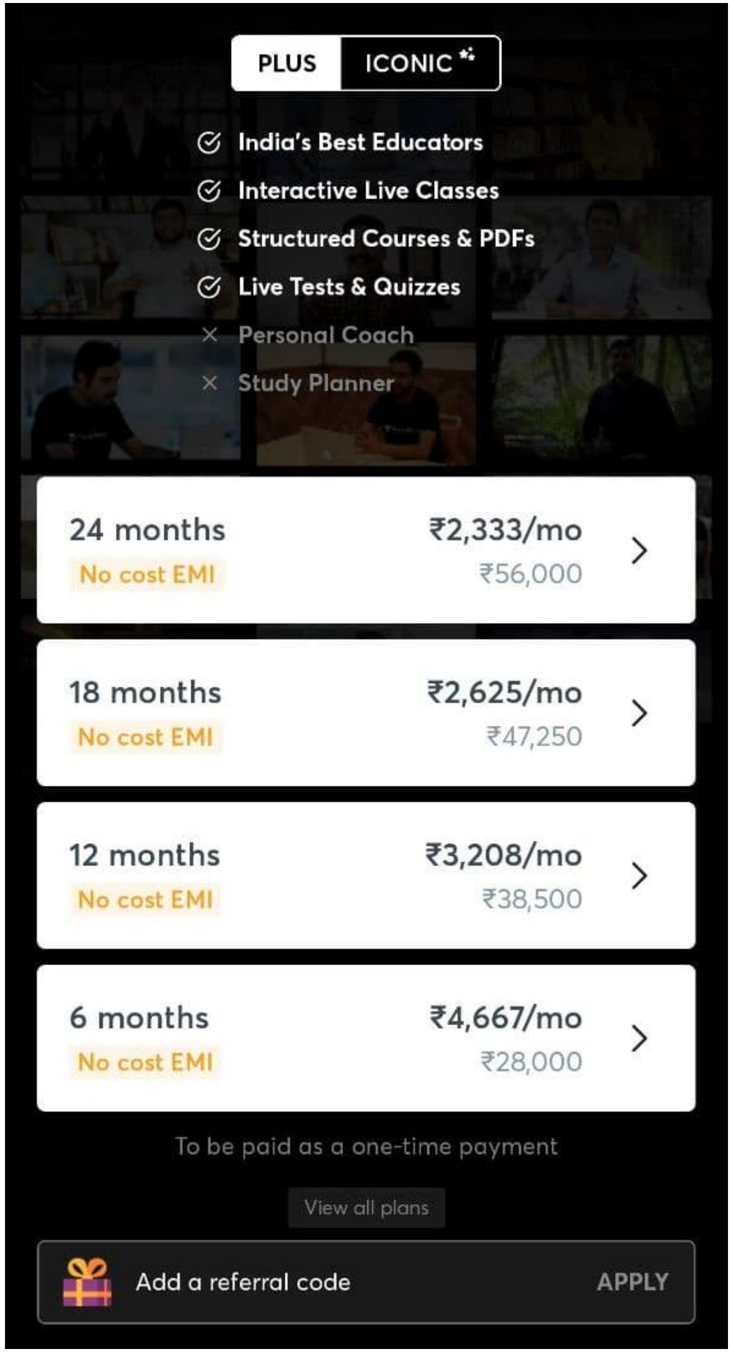
Q 13. A particle is moving in a circular path. The acceleration and momentum of the particle at a certain moment are $\vec{a} = (4\hat{\imath} + 3\hat{\jmath})$ m/s^2 and $\vec{p} = (8\hat{\imath} - 6\hat{\jmath})$ kg-m/s. The motion of the particle is:
(a) uniform circular motion
(b) accelerated circular motion
(c) deaccelerated circular motion
(d) we cannot say anything with $\vec{a}$ and $\vec{p}$ only

Q 14. **Column I** contain some questions and **Column II** contains some answers. Match the correct answer of question.

	Column I		Column II
(A)	Particle moving on a straight line path with constant velocity	(p)	Magnitude of net force is constant
(B)	Particle moving on a straight line path with constant acceleration	(q)	Direction of net force is fixed
(C)	Particle moving in a circle with constant speed	(r)	Magnitude of net force is variable
(D)	Particle moving along an ellipse with constant speed	(s)	Direction of net force changes with time

Answer Key

Q.1 d	Q.2 c	Q.3 b	Q.4 a, c	Q.5 b
Q.6 A-R, B-Q, C-S, D-P	Q.7 d	Q.8 c	Q.9 b	Q.10 c
Q.11 d	Q.12 a	Q.13 b	Q.14 A(p), B(p, q), C(p, s), D(r, s)	



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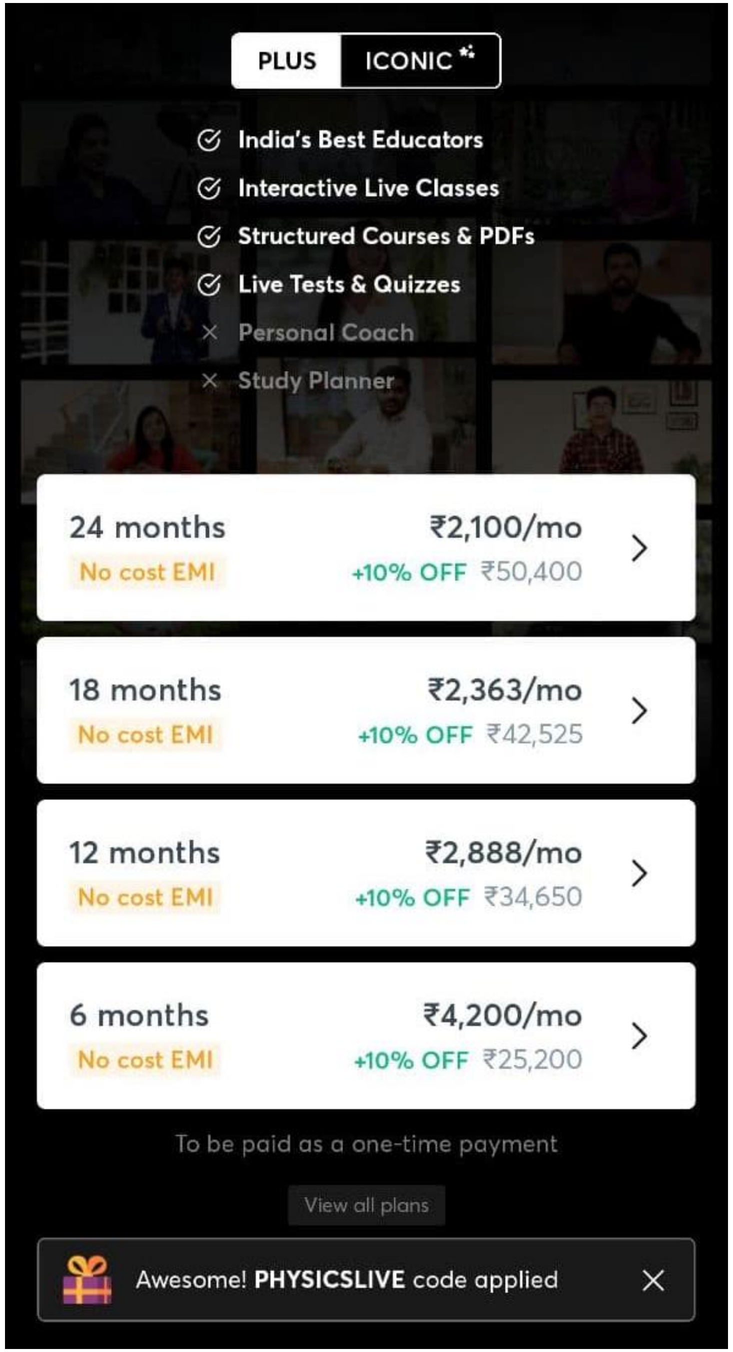

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Written Solution

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

By Physicsaholics Team

Q1) Two bodies A and B are moving with same constant speed v in clockwise direction in a horizontal circle of radius R and are initially diametrically opposite as shown in figure. The particle B now achieves a tangential acceleration a m/s^2. Then :

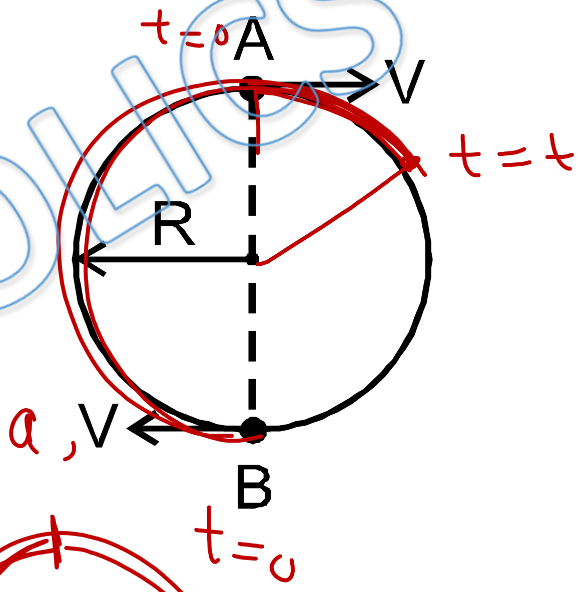
$s_A = Vt$

$s_B = Vt + \frac{1}{2}at^2$

$s_B - s_A = \pi R$

$\frac{1}{2}at^2 = \pi R$

$t = \sqrt{\frac{2\pi R}{a}}$



(a) they collide after time $\sqrt{\frac{\pi R}{a}}$

(b) they collide after time $2\sqrt{\frac{\pi R}{a}}$

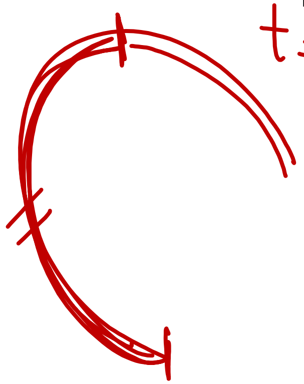
$V_B = V + a\sqrt{\frac{2\pi R}{a}}$

$V_B = V + \sqrt{2a\pi R}$

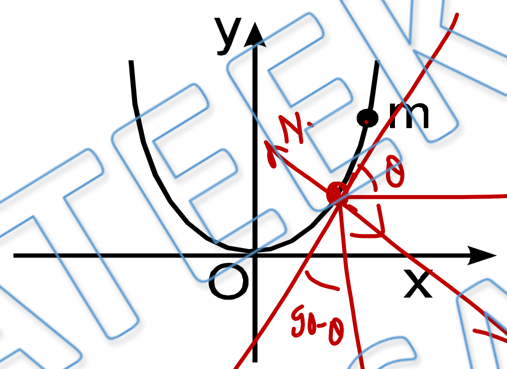
(c) relative velocity just before collision is $\sqrt{\pi a R}$

(d) relative velocity just before collision is $\sqrt{2\pi a R}$

$V_{rel} = \sqrt{2a\pi R}$



Q2) A bead of mass m is located on a parabolic wire with its axis vertical and vertex at the origin as shown in figure and whose equation is $x^2 = 4ay$. The wire frame is fixed in vertical plane and the bead can slide on it without friction. The bead is released from the point y = 4a on the wire frame from rest. The tangential acceleration of the bead when it reaches the position given by y = a is :



$a_T = g\sin\theta$

$= g\sin 45$

$= g/\sqrt{2}$

$x^2 = 4ay \Rightarrow \frac{2x}{4a} = \frac{dy}{dx}$

$\tan\theta = \frac{dy}{dx} = \frac{x}{2a} = \frac{2a}{2a}$

$\tan\theta = 1$

$\theta = 45$

(a) $\frac{g}{2}$ (b) $\frac{\sqrt{3}g}{2}$ (c) $\frac{g}{\sqrt{2}}$ (d) $\frac{g}{\sqrt{5}}$

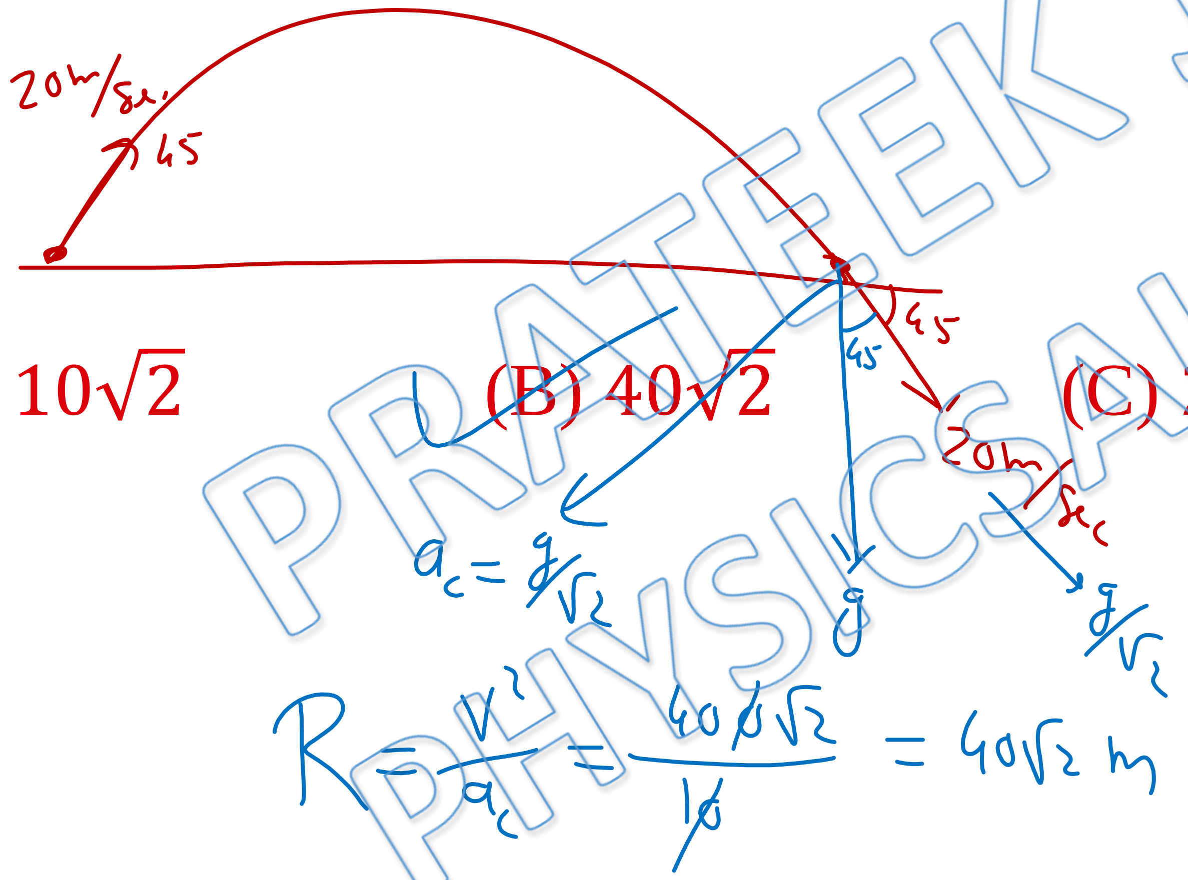
$y = a$

$x^2 = 4a^2$

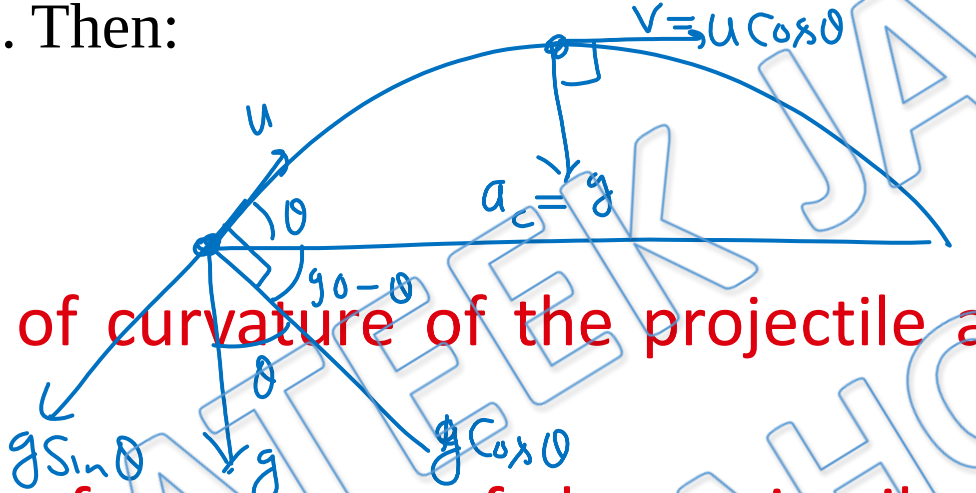
$x = \pm 2a$

Q3) A heavy particle is projected from a point on the horizontal at an angle 45^0 with the horizontal with a speed of 20m/s. Then the radius of the curvature of its path at the instant of crossing the same horizontal is ________.

(A) $10\sqrt{2}$ (B) $40\sqrt{2}$ (C) $20\sqrt{2}$ (D) None of these



Q4) A particle is fired from a point on the ground with speed u making an angle θ with the horizontal. Then:



At topmost point

$$R = \frac{v^2}{a_c} = \frac{u^2\cos^2\theta}{g}$$

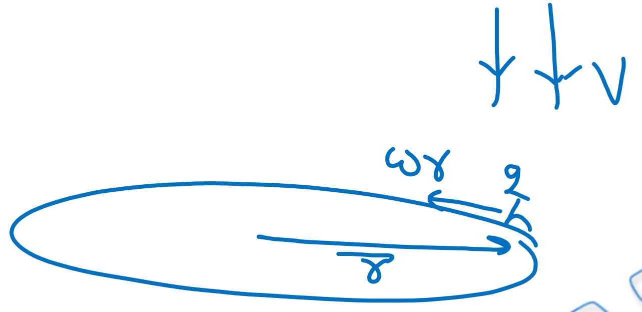
(a) the radius of curvature of the projectile at the heighest point is $\dfrac{u^2\cos^2\theta}{g}$

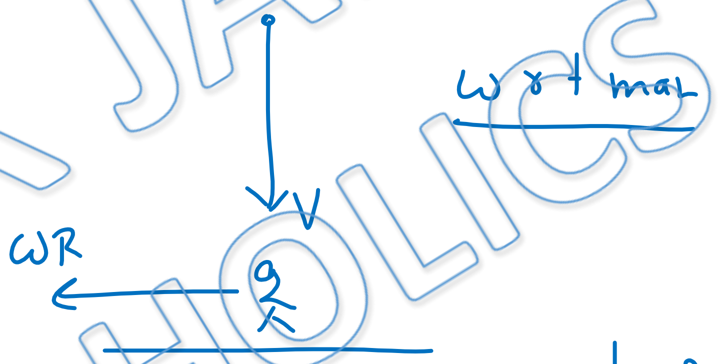
(b) the radius of curvature of the projectile at the highest point is $\dfrac{u^2\sin^2\theta}{g}$

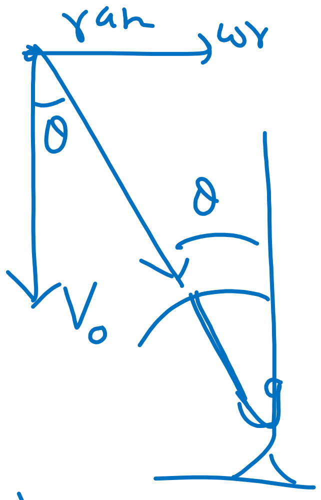
(c) at the point of projection tangential acceleration is g sin θ

(d) at the point of projection tangential acceleration is g cos θ

Q5) An open merry – go – round rotates at an angular velocity ω . A person stands in it at a distance r from the rotational axis. It is raining and raindrops fall vertically with a velocity v. The person should hold an umbrella to protect himself with axis of umbrella tilted with vertical at angle:







$\tan\theta = \frac{\omega r}{V_0}$

$\theta = \tan^{-1}\left(\frac{\omega r}{V_0}\right)$

(a) $tan^{-1}(v_0/r\omega)$ in the plane perpendicular to $\vec{r}$

(b) $tan^{-1}(r\omega/v_0)$ in the plane perpendicular to $\vec{r}$

(c) $tan^{-1}(r\omega/v_0)$ in the plane through $\vec{r}$

(d) None

Q6) For a moving particle if a_r is radial acceleration and a_T is tangential acceleration, then match the motion of column II with conditions given in column I.

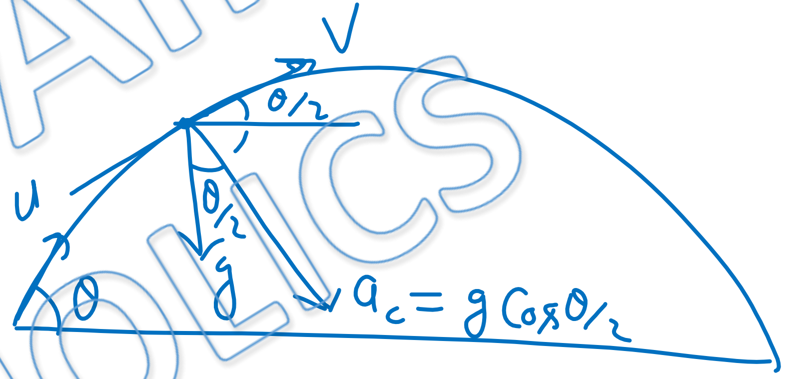
Column I	Column II
(A) $a_r = 0, a_T \neq 0$	p) Non uniform circular
(B) $a_r \neq 0, a_T = 0$	q) Uniform circular
(C) $a_r = 0, a_T = 0$	r) accelerated translatory
(D) $a_r \neq 0, a_T \neq 0$	s) uniform translatory

direction is constant

Q7) A particle is projected with a velocity u at an angle θ with the horizontal. Find the radius of the curvature of the parabola traced out by the particle at the point where velocity makes an angle (θ/2) with the horizontal.

Since $u_x = \text{Const} \Rightarrow V\cos\frac{\theta}{2} = u\cos\theta$

$$V = \frac{u\cos\theta}{\cos\frac{\theta}{2}}$$



(a) $\dfrac{u^2\cos^2\theta}{2g\cos^3\frac{\theta}{2}}$

(b) $\dfrac{2u^2\cos^2\theta}{g\cos^3\frac{\theta}{2}}$

(c) $\dfrac{3u^2\cos^2\theta}{2g\cos^3\frac{\theta}{2}}$

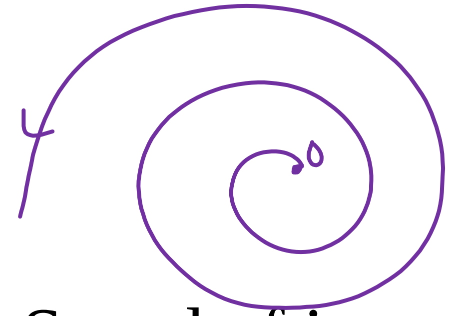
(d) $\dfrac{u^2\cos^2\theta}{g\cos^3\frac{\theta}{2}}$ ✓

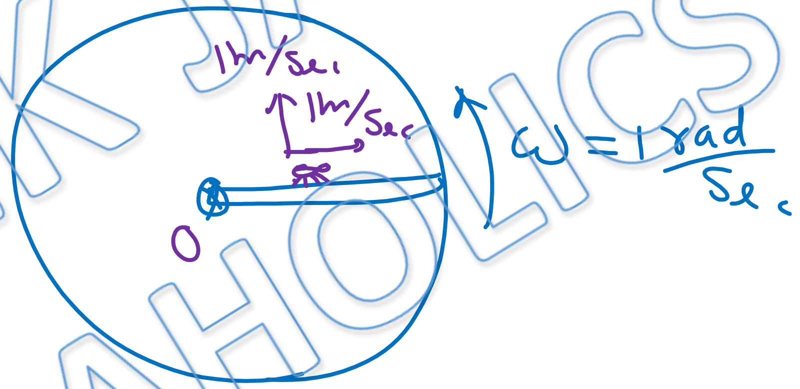
$$R = \frac{V^2}{a_c} = \frac{u^2\cos^2\theta}{\cos^2\frac{\theta}{2}\; g\cos\frac{\theta}{2}}$$

$$= \frac{u^2\cos^2\theta}{g\cos^3\frac{\theta}{2}}$$

Comprehension

Q8) A horizontal rod is rotating about a vertical axis passing through its one end with constant angular velocity 1 rad/sec.An insect starts moving on it from axis with constant speed 1m/sec relative to rod.





(Q) Speed of insect at t = 1 sec is

(a) 1m/sec (b) 2m/sec (c) $\sqrt{2}$ m/sec (d) $2\sqrt{2}$ m/sec

at t=1, $r = 1 \times 1 = 1m$

velocity due to rotation $= \omega r = 1\ m/sec$

Q9) Tangential acceleration of insect at t = 1 sec

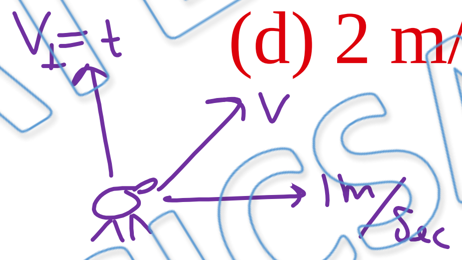
$$a_T = \frac{dv}{dt}$$

(a) $\sqrt{2}\ m/sec^2$

(b) $\frac{1}{\sqrt{2}}\ m/sec^2$ ✓

(c) $1\ m/sec^2$

(d) $2\ m/sec^2$



at t = t

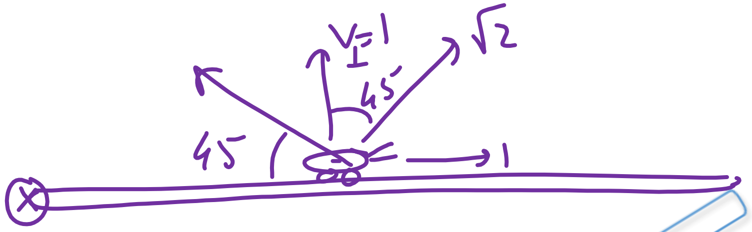
$r = vt = t$

$V_\perp = \omega r = t$

$$V = \sqrt{1^2 + t^2} = \sqrt{1+t^2} = (1+t^2)^{1/2}$$

$$a_T = \frac{dv}{dt} = \frac{1}{2}(1+t^2)^{-1/2} \times 2t = \frac{t}{\sqrt{1+t^2}} = \frac{1}{\sqrt{2}}$$

Q10) Direction of radial acceleration of insect at t = 1 is



(a) Along rod

(b) perpendicular to rod

(c) At angle 45^0 with rod

(d) None of these

Q11) For a particle moving along circular path, the radial acceleration a_r is proportional to time t. If a_t is the tangential acceleration, then which of the following will be independent of time t?

$a_r \propto t$

$a_r = c(t)$

$v^2 = crt$

(a) a_t (b) $a_r a_t$ (c) $\frac{a_r}{a_t}$ (d) $a_r(a_t)^2$ ✓

$V = c_1 t^{1/2}$

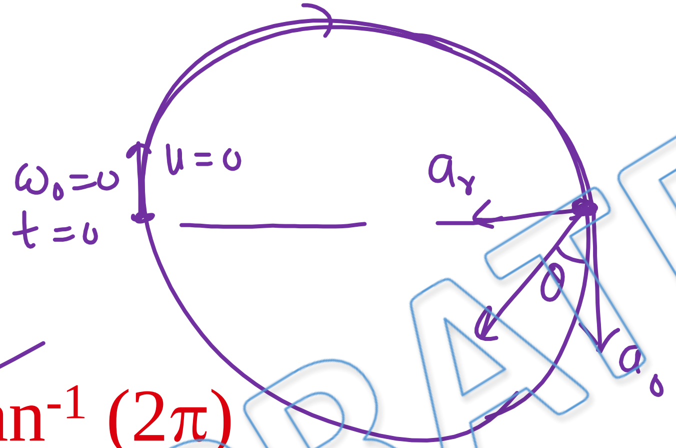
$a_T = \frac{dv}{dt} = \frac{1}{2} t^{-1/2}$

$a_T = \frac{1}{2\sqrt{t}} \Rightarrow a_T^2 t = \text{Const.}$

$a_T^2 a_r = \text{Const.}$

Q12) A particle starts travelling on a circle with constant tangential acceleration. The angle between velocity vector and acceleration vector, at the moment when particle completes half the circular track, is

$a_T = a_0$ (constant)



$$\tan\theta = \frac{a_r}{a_0} = \frac{2a_0\pi}{a_0} = 2\pi$$

$$\theta = \tan^{-1}(2\pi)$$

(a) $\tan^{-1}(2\pi)$ ✓ (b) $\tan^{-1}(\pi)$

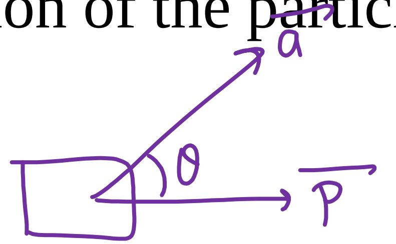
(c) $\tan^{-1}(3\pi)$ (d) zero

$$V^2 = u^2 + 2as$$

$$= 0 + 2a_0\pi R$$

$$a_r = \frac{V^2}{R} = 2a_0\pi$$

Q13) A particle is moving in a circular path. The acceleration and momentum of the particle at a certain moment are $\vec{a} = (4\hat{\imath} + 3\hat{\jmath})\ \mathrm{m/s^2}$ and $\vec{p} = (8\hat{\imath} - 6\hat{\jmath})\ \mathrm{kg\text{-}m/s}$. The motion of the particle is:



$\vec{a} \cdot \vec{p} = 48 - 18 = 30$

$\Rightarrow$ angle b/w $\vec{a}$ and $\vec{p}$ < 90

$\Rightarrow$ speed up

(a) uniform circular motion

(b) accelerated circular motion

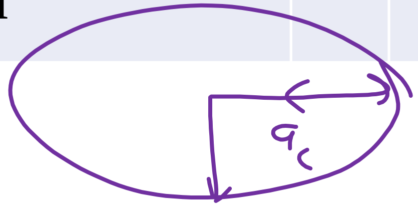
(c) deaccelerated circular motion

(d) we cannot say anything with $\vec{a}$ and $\vec{p}$ only

Q14) **Column I** contain some questions and **Column II** contains some answers. Match the correct answer of question.

	Column I		Column II
(A)	Particle moving on a straight line path with constant velocity	(p)	Magnitude of net force is constant
(B)	Particle moving on a straight line path with constant acceleration	(q)	Direction of net force is fixed
(C)	Particle moving in a circle with constant speed	(r)	Magnitude of net force is variable
(D)	Particle moving along an ellipse with constant speed	(s)	Direction of net force changes with time

$a_c = \frac{v^2}{R}$ = Constant
but direction is changing



$a_c = \frac{V^2}{R}$

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Chalo Niklo