Q.1 A particle is moving along a circular path with a constant speed. The acceleration of the particle is constant in -

(A) magnitude

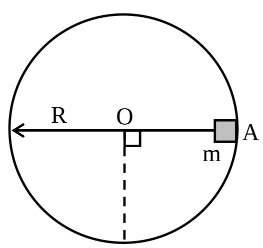
(B) direction

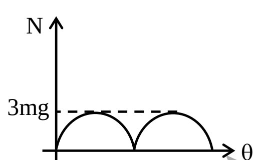
(C) both magnitude and direction

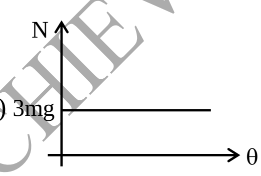
(D) neither magnitude nor direction **[A]**

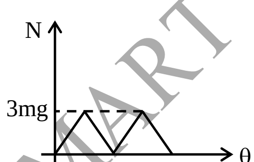
Sol. Only magnitude remain constant and direction changes

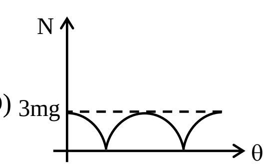
Q. 2 A particle of mass m is released from point A on smooth fixed circular track as shown. If the particle is released from rest at t = 0, then variation of normal reaction N with (θ) angular displacement from initial position is –



(A) 

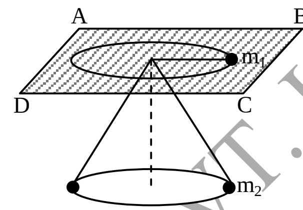
(B) 

(C) 

(D) 

[A]

`Q.3 ABCD is a smooth horizontal fixed plane on which mass m_1 = 0.1 kg is moving in a circular path of radius r = 1 m. It is connected by an ideal string which is passing through a smooth hole and connects of mass $m_2 = \frac{1}{\sqrt{2}}$ kg at the other end as shown. m_2 also moves in a horizontal circle of same radius of 1 m with a speed of $\sqrt{10}$ m/s. If g = 10 m/s^2 then the speed of m_1 is-

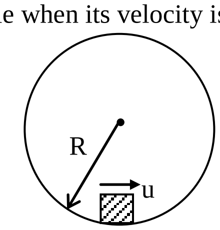


(A) $\sqrt{10}$ m/s (B) 10 m/s

(C) $\frac{1}{\sqrt{10}}$ m/s (D) None of these

[B]

Q.4 A particle is given an initial speed u inside a smooth spherical shell of radius R = 1 m that it is just able to complete the circle. Acceleration of the particle when its velocity is vertical is -



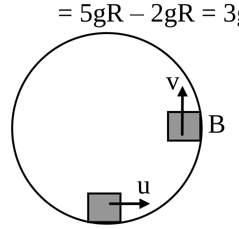
(A) g $\sqrt{10}$ (B) g

(C) g $\sqrt{2}$ (D) 3g **[A]**

Sol. **[A]** $u^2 = 5gR$

$\therefore v^2 = u^2 - 2gR$

$= 5gR - 2gR = 3gR$



Tangential acceleration at B is

$a_t = g$ (downwards)

Centripetal acceleration at B is

$$a_C = \frac{v^2}{R} = 3g$$

$\therefore$ Total acceleration will be

$$a = \sqrt{a_C^2 + a_t^2} = g\sqrt{10}$$

Q. 5 A particle moves in x-y plane. The position vector of particle at any time t is $\vec{r} = \{(2t)\hat{i} + (2t^2)\hat{j}\}$ m. The rate of change of θ at time t = 2s. (where θ is the angle which its velocity vector makes with positive x-axis) is

(A) $\frac{2}{17}$ rad/s (B) $\frac{1}{14}$ rad/s

(C) $\frac{4}{7}$ rad/s (D) $\frac{6}{5}$ rad/s

Sol. **[A]**

$x = 2t \quad \Rightarrow V_x = \frac{dx}{dt} = 2$

$y = 2t^2 \quad \Rightarrow v_y = \frac{dy}{dt} = 4t$

$\therefore \quad \tan\theta = \frac{v_y}{v_x} = \frac{4t}{2} = 2t$

Differentiating with respect to time we get,

$(\sec^2\theta)\frac{d\theta}{dt} = 2$

or $(1 + \tan^2\theta)\frac{d\theta}{dt} = 2$

or $(1 + 4t^2)\frac{d\theta}{dt} = 2$

or $\frac{d\theta}{dt} = \frac{2}{1+4t^2}$

$\frac{d\theta}{dt}$ at t = 2 s is $\frac{d\theta}{dt} = \frac{2}{1+4(2)^2} = \frac{2}{17}$ rad/s

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

(A) Uniform circular motion

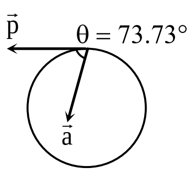
(B) accelerated circular motion

(C) decelerated circular motion

(D) We cannot say anything with $\vec{a}$ and $\vec{p}$ only

Sol. **[B]**

Angle between $\vec{a}$ and $\vec{p}$ is :



$\theta = \cos^{-1}\frac{\vec{a}.\vec{p}}{|\vec{a}||\vec{p}|}$

$= \cos^{-1}\left\{\frac{32-18}{\sqrt{(16+9)}\sqrt{(64+36)}}\right\}$

$= \cos^{-1}\left(\frac{14}{50}\right)$

θ = 73.73°

Since 0° < 90°, the motion is an acceleration one.

Q.7 A stone hanging from a massless string of length 15 m is projected horizontally with speed 147 m/s. Then the speed of the particle at the point where tension in string equals the weight of particle is –

(A) 10 m/s (B) 7 m/s

(C) 12 m/s (D) None of these

Sol. **[B]**

$T - mg\cos\theta = \frac{mv^2}{\ell}$ and $v^2 - u^2 = -2g\ell(1 - \cos\theta)$

also T = mg

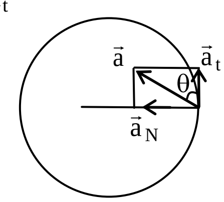
Q. 8 A point on the periphery of rotating disc has its acceleration vector making on angle 30º with velocity vector then the ration of magnitude of centripetal acceleration to tangential acceleration is -

(A) sin30º (B) cos 30º

(C) tan 30º (D) None of these

Sol. **[C]**

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



Q.9 Check up the only correct statement in the following-

(A) A body has a constant velocity and still it can have a varying speed

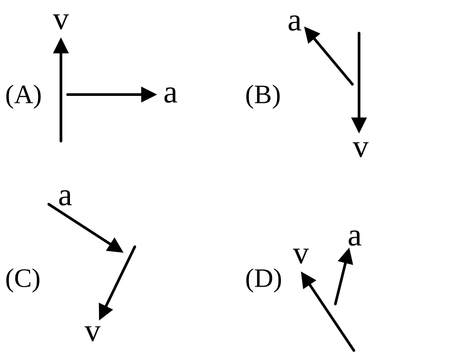
(B) A body has a constant speed but it can have a varying velocity

(C) A body having constant speed cannot have any acceleration

(D) A body in motion under a force acting upon it must always have work done upon it

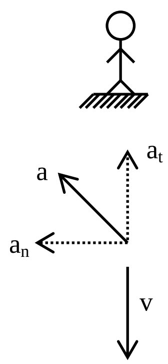
[B]

Q.10 Shown here are the velocity and acceleration vectors for an object in several different types of motion. In which case is the object slowing down and turning to the right ?

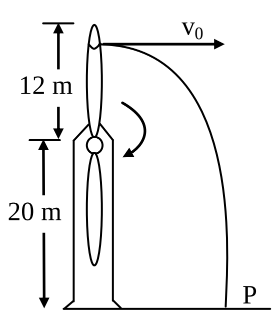


[B]

Sol. From observer point of view a_t decreases v and a_n makes the path of object curved turning to the right.



`Q.11 A wind farm generator uses a two-bladed propeller mounted on a pylon at a height of 20 m. The length of each propeller blade is 12 m. A tip of the propeller breaks off when the propeller is vertical. At that instant, the period of the motion of the propeller is 1.2 second. The fragment files off horizontally, falls and strikes the ground at point P.

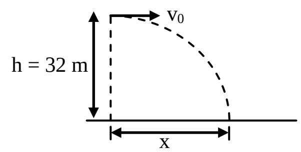


In figure, the distance from the base of the pylon to the point where the fragment strikes the ground is closest to -

(A) 120 m (B) 130 m

(C) 140 m (D) 160 m **[D]**

Sol.



$x = v_0 t$

$h = \frac{1}{2} gt^2$

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 32}{10}} = \frac{8}{\sqrt{10}}$

$v_0 = \omega r = \frac{2\pi}{T} \times 12 = \frac{2\pi}{1.2} \times 12 = 20\pi$

$x = 20\pi \times \frac{8}{\sqrt{10}} = \frac{160 \times 3.14}{3.162}$

$x = 160$ m

Q.12 A circular disc of radius r = 5 m is rotating in horizontal plane about y-axis. y-axis a vertical axis passing through the centre of disc and x-z is the horizontal plane at ground. The height of disc above ground is h = 5 m. Small particles are ejecting from disc in horizontal direction with speed 12 m/s from the circumference of disc then the distance of these particles from origin when they hits x – z plane is -

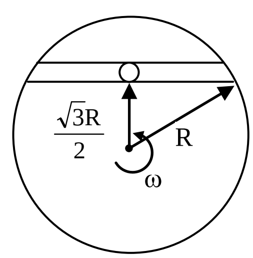
(A) 5 m (B) 12 m

(C) 13 m (D) None of these **[C]**

Sol. $R = u\sqrt{\frac{2h}{g}} = 12\sqrt{\frac{2 \times 5}{10}} = 12$ m

$\therefore$ Distance from origin = $\sqrt{5^2 + (12)^2} = 13$ m

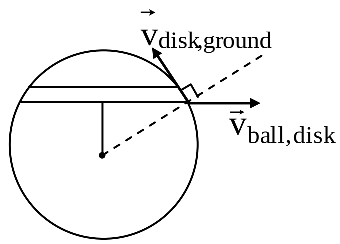
Q.13 A horizontal disk is rotating with angular velocity 'ω' about a vertical axis passing through its centre. A ball is placed at the centre of groove and pushed slightly. The velocity of ball when it comes out of the groove –

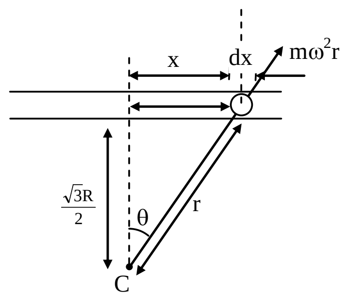


(A) $\frac{\sqrt{3}}{2}\omega R$ (B) $\frac{\omega R}{2}$

(C) ωR (D) $\frac{\omega R}{\sqrt{2}}$ **[A]**

Sol. Let us consider motion of ball with respect to disk





Net force along groove = $m\omega^2 r \sin\theta$

$= m\omega^2 r \frac{x}{r}$

$= m\omega^2 x$

$\therefore \quad ma = m\omega^2 x$

$\Rightarrow v\frac{dv}{dx} = \omega^2 x$

$\Rightarrow \quad v = \frac{\omega R}{2}$

$\vec{v}_{Ball,Ground} = \vec{v}_{Ball,Disk} + \vec{v}_{Ball,Ground}$

$\therefore \quad \vec{v}_{Ball,Ground}$

$$= \left\{(\omega R)^2 + \left(\frac{\omega R}{2}\right)^2 + 2(\omega R)\left(\frac{\omega R}{2}\right)\cos 120°\right\}^{\frac{1}{2}}$$

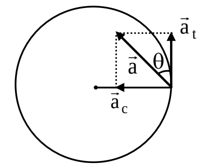
$$= \frac{\sqrt{3}}{2}\omega R$$

Q.14 A particle is moving in a circular path and its acceleration vector is making an angle of 30° with the velocity vector, then the ratio of centripetal acceleration to its tangential acceleration is –

(A) $\frac{1}{2}$ (B) $\frac{\sqrt{3}}{2}$

(C) $\frac{1}{\sqrt{3}}$ (D) $\sqrt{3}$ **[C]**

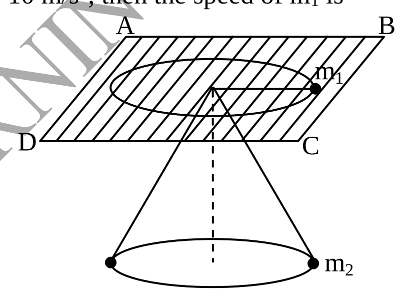
Sol.



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

$\therefore \quad \frac{a_c}{a_t} = \tan 30° = \frac{1}{\sqrt{3}}$

Q. 15 ABCD is a smooth horizontal fixed plane on which mass m_1 = 0.1 kg is moving in a circular path of radius 1 m. It is connected by an ideal string which is passing through a smooth hole and connects mass $m_2 = \frac{1}{\sqrt{2}}$ kg at the other end as shown. m_2 also moves in a horizontal circle of same radius of 1 m with a speed of $\sqrt{10}$ m/s. If g = 10 m/s^2, then the speed of m_1 is –

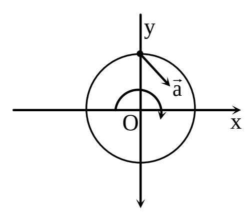


(A) $\sqrt{10}$ m/s (B) 10 m/s

(C) $\frac{1}{\sqrt{10}}$ m/s (D) None of these **[B]**

Sol. $T = m_2\sqrt{g^2 + \left(\frac{v_2^2}{r}\right)^2} = \frac{m_1 v_1^2}{r}$

Q.16 A body is moving is x-y plane as shown in a circular path of radius 2 m. At a certain instant when the body is crossing the positive y-axis its acceleration is $(6\hat{i} - 8\hat{j})$ m/s^2. Then its angular acceleration and angular velocity at this instant will be -



(A) $-3\hat{k}$ rad/s^2 and $-2\hat{k}$ rad/s respectively

(B) $+3\hat{k}$ rad/s^2 and $+2\hat{k}$ rad/s respectively

(C) $-4\hat{k}$ rad/s^2 and $-\sqrt{3}\hat{k}$ rad/s respectively

(D) $+4\hat{k}$ rad/s^2 and $+\sqrt{3}\hat{k}$ rad/s respectively

[A]

Sol. $\vec{a} = 6\hat{i} - 8\hat{j}$

$\therefore$ $a_r = 8$ and $a_t = 6$

$r\omega^2 = 8$ and $r\alpha = 6$

Q.17 Position vector of a particle moving in x-y plane at time t is $\vec{r} = a\,(1 - \cos \omega t)\,\hat{i} + a \sin \omega t\,\hat{j}$. The path of the particle is :

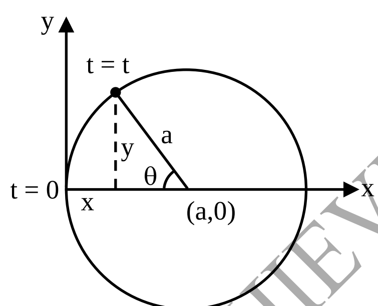
(A) a circle of radius **a** and centre at (a, 0)

(B) a circle of radius **a** and centre at (0, 0)

(C) an ellipse

(D) neither a circle nor an ellipse **[A]**

Sol. Particle is moving in a circle of radius **a** and centre (a, 0) with constant angular velocity ω. At time t = 0 particle is at origin and it starts rotating clockwise. At time t it has rotated an angle θ given by :



$\theta = \omega t$

$y = a \sin \theta = a \sin \omega t$

and $x = a - a \cos \theta = a\,(1 - \cos \omega t)$

$\therefore \vec{r} = a\,(1 - \cos \omega t)\,\hat{i} + a \sin \omega t\,\hat{j}$

Q.18 A simple pendulum consisting of a mass M attached in a string of length L is released from rest at an angle **α**. A pin is located at a distance ***l*** below the pivot point. When the pendulum swings down, the string hits the pin as shown in the figure. The maximum angle θ which string makes with the vertical after hitting the pin is –

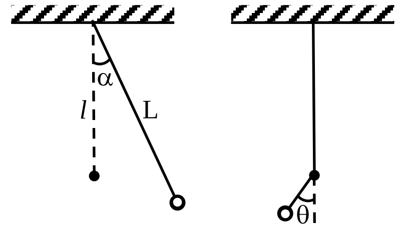


Fig.

(A) $\cos^{-1}\left[\dfrac{L\cos\alpha + l}{L + l}\right]$

(B) $\cos^{-1}\left[\dfrac{L\cos\alpha + l}{L - l}\right]$

(C) $\cos^{-1}\left[\dfrac{L\cos\alpha - l}{L - l}\right]$

(D) $\cos^{-1}\left[\dfrac{L\cos\alpha - l}{L + l}\right]$ **[C]**

Sol. At the bottom most point, square of speed of bob,

$v^2 = 2\,gL(1 - \cos \alpha)$

It will rise further to a height,

$h = \dfrac{v^2}{2g} = L(1 - \cos \alpha)$

or $(L - l)\,(1 - \cos \theta) = L(1 - \cos \alpha)$

$\therefore\ \theta = \cos^{-1}\left[\dfrac{L\cos\alpha - l}{L - l}\right]$

Q.19 A stone tied to a string of length L is whirled in a vertical circle with the other end of the string at the centre. At a certain instant of time, the stone is at its lowest position, and has a speed **u**. The magnitude of the change in its velocity as it reaches a position where the string is horizontal is –

(A) $\sqrt{u^2 - 2gL}$ (B) $\sqrt{2gL}$

(C) $\sqrt{u^2 - gL}$ (D) $\sqrt{2(u^2 - gL)}$

[D]

Sol. From energy conservation

$v^2 = u^2 - 2gL$ … (1)

Now since the two velocity vectors shown in figure are mutually perpendicular, hence the magnitude of change of velocity will be given by

$|\Delta \vec{v}| = \sqrt{u^2 + v^2}$

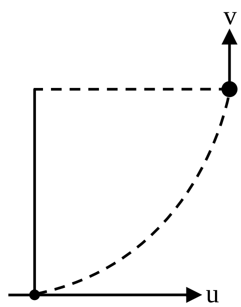


Fig.

Substituting value of v^2 from Eq. (1)

$$|\Delta \vec{v}| = \sqrt{u^2 + u^2 - 2gL}$$

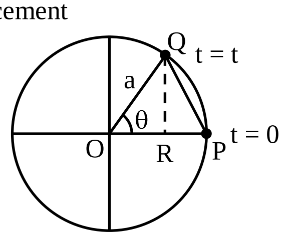
$$|\Delta \vec{v}| = \sqrt{2(u^2 - gL)}$$

Q.20 The magnitude of displacement of a particle moving in a circle of radius a with constant angular speed ω varies with time t as –

(A) $2a \sin \omega t$ (B) $2a \sin \frac{\omega t}{2}$

(C) $2a \cos \omega t$ (D) $2a \cos \frac{\omega t}{2}$ **[B]**

Sol. In time t particle has rotated an angle $\theta = \omega t$. Displacement

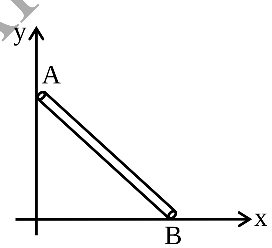


$$s = PQ = \sqrt{QR^2 + PR^2}$$

$$= \sqrt{(a \sin \omega t)^2 + (a - a \cos \omega t)^2}$$

$$s = 2a \sin \frac{\omega t}{2}$$

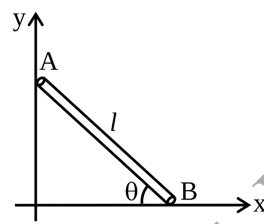
Q.21 A rigid rod leans against a vertical wall (y-axis) as shown in figure. The other end of the rod is on the horizontal floor. Point A is pushed downwards with constant velocity. Path of the centre of the rod is –



(A) a straight line passing through origin
(B) a straight line not passing through origin
(C) a circle of radius $l/2$ and centre at origin
(D) a circle of radius $l/2$ but centre not at origin

[C]

Sol. Let l be the length of the rod and θ the angle of rod with x-axis (horizontal) at some instant of time. Co-ordinates of the centre of rod at this instant of time are



$$x = \frac{l}{2} \cos \theta$$

and $$y = \frac{l}{2} \sin \theta$$

Squaring and adding Eqs. (1) and (2), we get:

$$x^2 + y^2 = \frac{l^2}{4}$$

Which is an equation of a circle of radius $\frac{l}{2}$ and centre at origin.

Q.22 A solid body rotates about a stationary axis so that its angular velocity depends on the rotation angle ϕ as $\omega = \omega_0 - k\phi$, where ω_0 and k are positive constants. At the moment t = 0, the angle $\phi = 0$. Find the time dependence of rotation angle-

(A) $K.\ \omega_0 e^{-kt}$ (B) $\frac{\omega_0}{K}\ [e^{-kt}]$

(C) $\frac{\omega_0}{K}\ [1 - e^{-kt}]$ (D) $\frac{K}{\omega_0}\ [e^{-kt} - 1]$

[C]

Q.23 A point moves along a circle with velocity v = at where a = 0.5 m/sec^2. Then the total acceleration of the point at the moment when it covered $(1/10)^{th}$ of the circle after beginning of motion-

(A) 0.5 m/sec^2 (B) 0.6 m/sec^2

(C) 0.7 m/sec^2 (D) 0.8 m/sec^2 **[D]**

Q.24 Two cars having masses m_1 and m_2 move in circles of radius r_1 and r_2. If they complete the circle in equal time. The ratio of their angular speeds ω_1/ω_2 is-

(A) $\frac{m_1}{m_2}$ (B) $\frac{r_1}{r_2}$

(C) $\frac{m_1 r_1}{m_2 r_2}$ (D) 1 **[D]**

Q.25 When a particle moves in a circle with a uniform speed -

(A) its velocity and acceleration are both constants

(B) its velocity is constant but the acceleration changes

(C) its acceleration is constant but the velocity changes

(D) its velocity and acceleration both change **[D]**

Q.26 A stone of mass m tied to a string of length ℓ is rotated in a circle with the other end of the string as the centre. The speed of stone is v. If the string breaks, the stone will move -

(A) towards centre (B) away from centre

(C) along tangent (D) will stop **[C]**

Q.27 Angular position of a line of a disc of radius r = 6 cm is given by $\theta = 10 - 5t + 4t^2$ rad. the average angular speed between 1 and 3 s is-

(A) π rad/s (B) 11 rad/s

(C) 22 rad/s (D) 5.5 rad/s **[B]**

Q.28 In the above question linear speed of a point on the rim at 2s is-

(A) 0.33 m/s (B) 0.66 m/s

(C) 1 m/s (D) 1.32 m/s **[B]**

Q.29 At t = 0 a fly wheel is rotating at 50 rpm. A motor gives it a constant angular acceleration of 0.5 rad/s^2 until it reaches 100 rpm. the motor is then disconnected. How many revolutions are completed at t = 20 s ?

(A) 25 rev (B) 29 rev

(C) 20 rev (D) 15 rev **[B]**

Q.30 A 30 cm diameter turn table starts from rest and takes 2 s to reach its final rotation rate of 33.5 rpm; the angular acceleration is-

(A) 1.75 rad/s^2 (B) 1.25 rad/s^2

(C) 2 rad/s^2 (D) 1 rad/s^2 **[A]**

Q.31 A stone is moved round a horizontal circle with a 20 cm long string tied to it. If centripetal acceleration is 9.8 m/s^2, then its angular velocity will be-

(A) 7 rad/s (B) 22/7 rad/s

(C) 49 rad/s (D) 14 rad/s **[A]**

Q.32 A car is moving in a circular path of radius 500m with a speed of 30m/sec. If its speed is increasing at the rate of 2m/sec^2, the resultant acceleration will be -

(A) 2 m/sec^2 (B) 2.5 m/sec^2

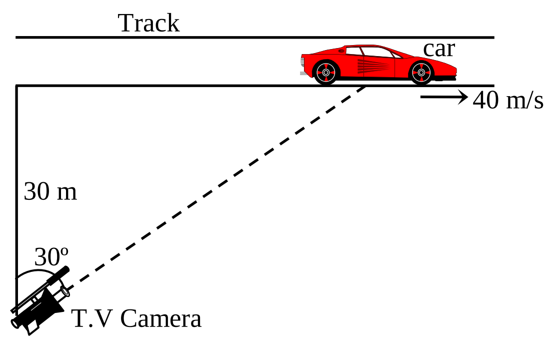
(C) 2.7 m/sec^2 (D) 4 m/sec^2 **[C]**

Q.33 An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 r.p.m. The acceleration of a point on the tip of the blade is about-

(A) 1600 m/sec^2 (B)4740 m/sec^2

(C) 2370 m/sec^2 (D) 5055 m/sec^2 **[B]**

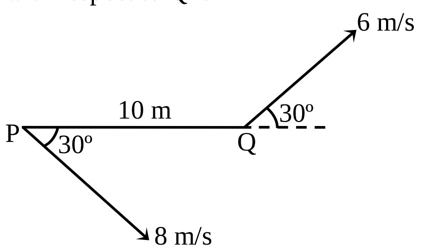
Q.34 A racing car is travelling along a track at a constant speed of 40 m/s. A T.V. camera men is recording the event from a distance of 30m directly away from the track as shown in figure. In order to keep the car under view in the position shown, the angular speed with which the camera should be rotated, is-



(A) 4/3 rad/sec (B) 3/4 rad/sec

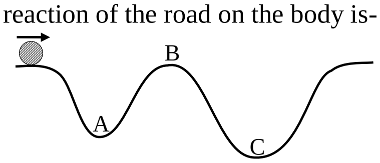
(C) $8/3\sqrt{3}$ rad/sec (D) 1 rad/sec **[B]**

`Q.35 Two moving particles P and Q are 10 m apart at a certain instant. The velocity of P is 8m/s making an angle 30º with the line joining P and Q and that of Q is 6m/s making an angle 30º with PQ as shown in the figure. Then angular velocity of P with respect to Q is-



(A) Zero (B) 0.1 rad/sec
(C) 0.4 rad/sec (D) 0.7 rad/sec **[D]**

Q.36 A body moves along an uneven horizontal road surface with constant speed at all points. The normal reaction of the road on the body is-



(A) Maximum at A
(B) Maximum at B
(C) Minimum at C
(D) The same at A,B and C **[A]**

Q.37 A particle of mass m rotates in a circle of radius a with a uniform angular speed ω. It is viewed from a frame rotating about the Z-axis with a uniform angular speed ω_o. The centrifugal force on the particle is-

(A) $m\omega^2 a$ (B) $m\omega_0^2 a$
(C) $m\left(\frac{\omega+\omega_0}{2}\right)^2 a$ (D) $m\omega\,\omega_o\, a$ **[B]**

Q.38 A uniform circular ring of mass per unit length λ and radius R is rotating with angular velocity ω about its own axis in a gravity free space. Tension in the ring is-

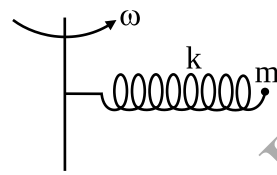
(A) Zero (B) $\frac{1}{2}\lambda R^2 \omega^2$
(C) $\lambda R^2 \omega^2$ (D) $\lambda R \omega^2$ **[C]**

Q.39 A uniform rod of mass m and length ℓ rotates in a horizontal plane with an angular velocity ω about a vertical axis passing through one end. The tension in the rod at distance x from the axis is-

(A) $\frac{1}{2} m\omega^2 x$ (B) $\frac{1}{2} m\omega^2 \frac{x^2}{\ell}$
(C) $\frac{1}{2} m\omega^2 \ell\left(1-\frac{x^2}{\ell}\right)$ (D) $\frac{1}{2}\cdot\frac{m\omega^2}{\ell}[\ell^2 - x^2]$

[D]

Q.40 A particle of mass m is fixed to one end of a light spring of force constant k and unstretched length ℓ. The system is rotated about the other end of the spring with an angular velocity ω, in gravity free space. The increase in length of the spring will be-

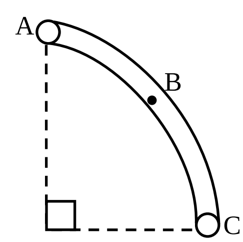


(A) $\frac{m\omega^2\ell}{k}$ (B) $\frac{m\omega^2\ell}{k-m\omega^2}$
(C) $\frac{m\omega^2\ell}{k+m\omega^2}$ (D) None of these **[B]**

Q.41 A railway track is banked for a speed v, by making the height of the outer rail (h) higher than that of the inner rail. The distance between the rails is d. The radius of curvature of the track is r-

(A) $\frac{h}{d}=\frac{v^2}{rg}$ (B) $\tan\left(\sin^{-1}\frac{h}{d}\right)=\frac{v^2}{rg}$
(C) $\tan^{-1}\left(\frac{h}{d}\right)=\frac{v^2}{rg}$ (D) $\frac{h}{r}=\frac{v^2}{dg}$ **[A]**

Q.42 The tube AC forms a quarter circle in a vertical plane. The ball B has an area of cross-section slightly smaller than that of the tube, and can move without friction through it. B is placed at A and displaced slightly. It will-



(A) always be in contact with the inner wall of the tube
(B) always be in contact with the outer wall of the tube
(C) initially be in contact with the inner wall and later with the outer wall
(D) initially be in contact with the outer wall and later with the inner wall **[C]**

Q.43 A particle is acted upon by a constant force always normal to the direction of motion of the particle. It is therefore inferred that-

(i) Its velocity is constant

(ii) It moves in a straight line

(iii) Its speed is constant

(iv) It moves in circular path

(A) i , iv (B) iii, iv

(C) i, ii (D) i, ii, iii **[B]**

Q.44 A particle of mass m is observed from an inertial frame of reference and is found to move in a circle of radius r with a uniform speed v. The centrifugal force on it is-

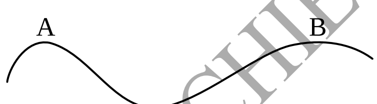
(A) $\frac{mv^2}{R}$ towards centre

(B) $\frac{mv^2}{R}$ away from centre

(C) $\frac{mv^2}{R}$ along tangent

(D) zero **[D]**

Q.45 A car moves at a constant speed on a road as shown in figure. The normal force by the road on the car is N_A and N_B when it is at the points A and B -



(A) $N_A = N_B$

(B) $N_A > N_B$

(C) $N_A < N_B$

(D) insufficient information **[C]**

Q.46 A motorcycle is going on an over bridge of radius R. The driver maintain a constant speed. As the motorcycle is ascending on the over bridge, the normal force on it -

(A) increases (B) decreases

(C) remains same (D) fluctuates **[A]**

Q.47 A rod of length L is pivoted at one end and is rotated with a uniform angular velocity in a horizontal plane. Let T_1 and T_2 be the tension at the points L/4 and 3L/4 away from the pivoted ends, then-

(A) $T_1 > T_2$

(B) $T_2 > T_1$

(C) $T_1 = T_2$

(D) inadequate information **[A]**

Q.48 Let θ denote the angular displacement of a simple pendulum oscillating in a vertical plane. If the mass of the bob is m. The tension in the string is mg cos θ -

(A) always (B) never

(C) at extreme position (D) at mean position

[C]

Q.49 Water in a bucket is whirled in a vertical circle with a string attached to it. The water does not fall down even when the bucket is inverted at the top of its path. We conclude that-

(A) $mg = \frac{mv^2}{R}$ (B) $mg > \frac{mv^2}{R}$

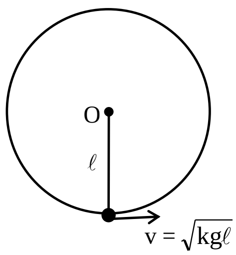
(C) $mg < \frac{mv^2}{R}$ (D) none of these **[C]**

Q.50 Three identical cars A, B and C are moving at the same speed on three bridges. The car A goes on plane bridge. B on a bridge convex upwards and car C on a bridge concave upwards. Let F_A, F_B and F_C be the normal forces exerted by the cars on the bridges when they are at the middle of bridge -

(A) F_A is maximum (B) F_B is maximum

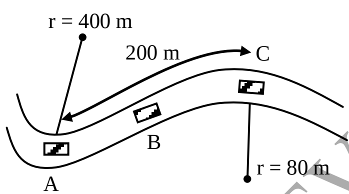
(C) F_C is maximum (D) $F_A = F_B = F_C$ **[C]**

Q.1 A pendulum of length ℓ is given a horizontal velocity $\sqrt{kg\ell}$ at the lowest point of vertical circular path as shown. In the subsequent motion the string gets slag at a certain point and the pendulum bob strikes the point of suspensión then the value of k is –



[0004]

Q.2 A 1500 kg car enters a section of curved road in the horizontal plane and slows down at a uniform rate from a speed of 100 km/hr at A to a speed of 50 km/hr as it passes C. The radius of curvature of the road at A is 400 m and at C is 80 m. The total horizontal force exerted by the road on tyres at position C is ...... N.



[4220]

Sol. $v_C^2 = v_A^2 + 2a_t S$

Tangential acceleration :

$a_t = \dfrac{v_C^2 - v_A^2}{2s}$ = 1.447 m/s^2

Normal acceleration at C is

$a_n = \dfrac{v^2}{r_C}$ = 2.41 m/s^2

Tangential force at C

$F_t = ma_t$

= 1500 × 1.447

= 2170 N

Normal force at C

$F_n = ma_n$

= 1500 (2.41)

= 3620 N

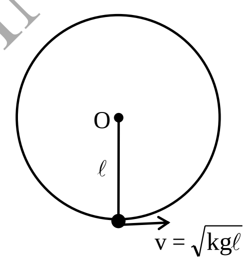
Total force at C

$F = \sqrt{F_n^2 + F_t^2}$

$F = \sqrt{(2170)^2 + (3620)^2}$

F = 4220 N

Q.3 A pendulum of length ℓ is given a horizontal velocity $\sqrt{kg\ell}$ at the lowest point of vertical circular path as shown. In the subsequent motion the string gets slag at a certain point and the pendulum bob strikes the point of suspensión then the value of k is -



Sol. **[0004]**

Q.4 A sphere of mass m = 0.5 kg carrying positive charge q = 110 μC is connected with a light, flexible and inextensible spring of length r = 60cm and whirled in a vertical circle. If a vertically upwards electric field of strength E = 10^5 N/C exists in the space then the minimum velocity of sphere in m/s required at highest point so that it may just complete the circle is (g = 10 m/s^2)

Sol. **[6]**

$F_E = qE = 11$ N

$F_g = mg = 5$N

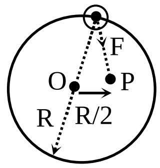
So Net force = F = 6N upward

$g_{eff} = \dfrac{F}{m} = \dfrac{6}{0.5}$ 12 m/s^2

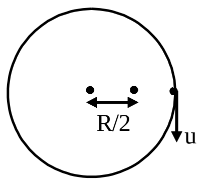
so $V_{min} = \sqrt{5g_{eff}\,\ell} = \sqrt{5 \times 12 \times (60 \times 10^{-2})}$

so V_{min} = 6 m/sec

Q.5 A small bead of mass m can move on a smooth circular wire (radius R) under the action of a force $F = \frac{Km}{r^2}$ directed (r = position of bead from P & K = constant) towards a point P within the circle at a distance R/2 from the centre. What should be the minimum velocity (in m/s) of bead at the point of the wire nearest the centre of force (P) so that bead will complete the circle (Take $\frac{k}{3R}$ = 8 unit)



Sol.[8] $U = -\int \vec{F}.\vec{dr}$



$U = -\frac{km}{r}$

$K_i + U_i = K_f + U_f$

$\frac{1}{2}mv^2 - \frac{Km}{\left(\frac{R}{2}\right)} = 0 - \frac{Km}{3R/2}$

$\frac{mv^2}{2} = \frac{2Km}{R} - \frac{-2Km}{3R}$

$\frac{mv^2}{2} = \frac{4Km}{3R}$

$V = \sqrt{\frac{8K}{3R}}$,V = 8 m/s

Q.6 A highway curve with a radius of 750 m is banked properly for a car traveling 120 kph. If a 1590 kg car takes the turn at a speed of 230 kph, how much sideways force must the tires exert against the road if the car does not skid?

Sol. 6230

Q.7 What is the minimum radius of a circle along which a cyclist can ride with a velocity 18 km/hr if the coefficient of friction between the tyres and the road is μ = 0.5 (take g = 10 m/s^2)

Sol.[5] $R = \frac{v^2}{\mu g} = \frac{5\times5}{0.5\times10}$ = 5 m