Circular Motion

Question1

A particle is in uniform circular motion. The equation of its trajectory is given by $(x-2)^2+y^2=25$, where x and y are in meter. The speed of the particle is $2\ \mathrm{ms}^{-1}$, when the particle attains the lowest ' y ' co-ordinate, the acceleration of the particle is (in ms^{-2})

KCET 2025

Options:

A. $0.4\hat{j}$

B. $0.8\hat{i}$

C. $0.8\hat{j}$

D. $0.4\hat{i}$

Answer: C

Solution:

To determine the acceleration of a particle in uniform circular motion, we start with the equation of the circle:

$(x-2)^2+y^2=25$

This equation represents a circle with its center at $(2,0)$ and a radius r of 5 meters, derived from:

$r^2=25 \quad \Rightarrow \quad r=5$

In uniform circular motion, the centripetal acceleration a_c is given by the formula:

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

Substituting the given speed $v=2$ m/s and the radius $r=5$ m:

$a_c = \frac{2^2}{5} = \frac{4}{5} = 0.8 \mathrm{~m/s}^2$

When the particle is at the lowest y-coordinate, it is at the point $(2, -5)$, assuming downward is along the negative y-axis. At this point, the acceleration vector, which is directed towards the center of the circle, points horizontally to the right towards the center $(2, 0)$. Therefore, the acceleration is entirely in the $\hat{\imath}$ direction:

$\overrightarrow{a_e} = 0.8 \hat{\imath} \mathrm{~m/s}^2$

Question2

An athlete runs along a circular track of diameter 80 m . The distance travelled and the magnitude of displacement of the athlete when he covers $3/4$ th of the circle is (in m)

KCET 2024

Options:

A. $60\pi, 40\sqrt{2}$

B. $40\pi, 60\sqrt{2}$

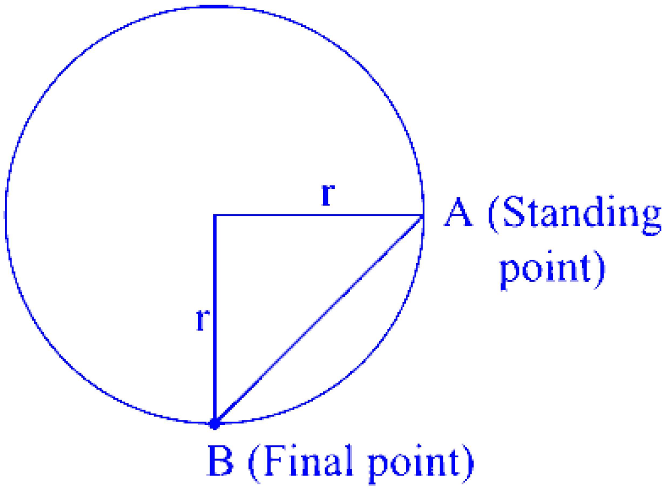
C. $120\pi, 80\sqrt{2}$

D. $80\pi, 120\sqrt{2}$

Answer: A

Solution:

Given, diameter, $d = 80$ m
$\therefore \quad r = 40$ m



Distance travelled after completion of $\frac{3}{4}$ revolution

$$= \frac{3}{4} \times 2\pi r = \frac{3\pi}{2} \times 40 = 60\pi \text{ m}$$

Displacement $= \sqrt{r^2 + r^2} = r\sqrt{2} = 40\sqrt{2} \text{ m}$

Question3

A particle is in uniform circular motion, related to one complete revolution of the particle, which among the statements is incorrect?

KCET 2023

Options:

A. Average acceleration of the particle is zero.

B. Displacement of the particle is zero.

C. Average speed of the particle is zero.

D. Average velocity of the particle is zero.

Answer: C

Solution:

Since, distance travelled by the body is not zero in one complete revolution, hence average speed is not zero.

In a circular motion, the displacement of the particle is zero, if it completes one revolution.

Therefore average velocity which is ratio of total displacement to the total time taken is also zero.

Question4

A car is moving in a circular horizontal track of radius $10 \mathrm{~m}$ with a constant speed of $10 \mathrm{~ms}^{-1}$. A bob is suspended from the roof of the car by a light wire of length $1.0 \mathrm{~m}$. The angle made by the wire with the vertical is (in rad)

KCET 2022

Options:

A. $\frac{\pi}{4}$

B. zero

C. $\frac{\pi}{3}$

D. $\frac{\pi}{6}$

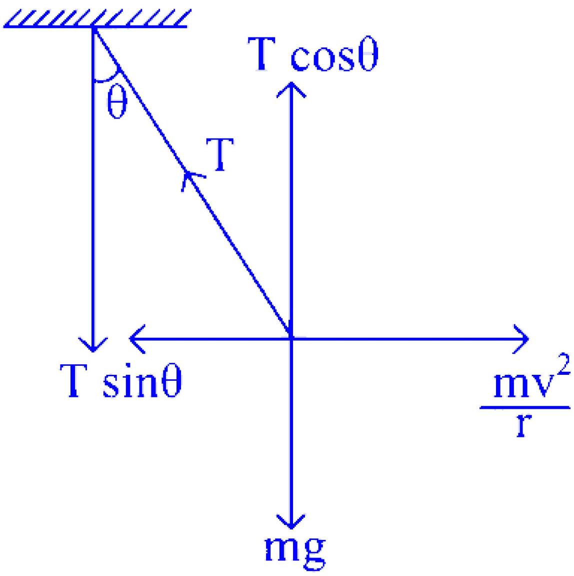
Answer: A

Solution:

Radius of circular track, $r=10 \mathrm{~m}$

speed of car, $v=10 \mathrm{~m} / \mathrm{s}$

The given situation is shown below



$T \sin\theta = \frac{mv^2}{r}$ .... (i)

$T \cos\theta = mg$ .... (ii)

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{T\sin\theta}{T\cos\theta} = \frac{mv^2/r}{mg} \Rightarrow \tan\theta = \frac{v^2}{rg} = \frac{10^2}{10\times 10} = 1$$

$$\Rightarrow \quad \tan\theta = \tan 45^\circ \Rightarrow \theta = 45^\circ = \frac{\pi}{4}\text{rad}$$

Question5

A coin placed on a rotating turn table just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turn table is doubled it will just slip at a distance of

KCET 2021

Options:

A. 1 cm

B. 2 cm

C. 4 cm

D. 8 cm

Answer: A

Solution:

When a coin is placed on a rotating turntable and is about to slip, the necessary centripetal force for maintaining its rotation is provided by friction. This relationship can be expressed as:

$m r \omega^2 = \mu m g$

where:

m is the mass of the coin,

r is the distance of the coin from the center of the turntable,

ω is the angular velocity of the turntable,

μ is the coefficient of friction, and

g is the acceleration due to gravity.

Since m, μ, and g are constant, the equation can be simplified to:

$r\omega^2 = \text{constant}$

From this, it follows that:

$r \propto \frac{1}{\omega^2}$

Thus, the relationship between the initial and the final conditions can be expressed as:

$\frac{r_2}{r_1} = \left(\frac{\omega_1}{\omega_2}\right)^2$

Given that $\omega_2 = 2\omega_1$ and $r_1 = 4\,\text{cm}$, we compute:

$\frac{r_2}{r_1} = \left(\frac{\omega_1}{2\omega_1}\right)^2$

Therefore,

$r_2 = \frac{r_1}{4} = \frac{4}{4} = 1\,\text{cm}$

Question6

One end of a string of length l is connected to a particle of mass m and the other to a small peg on a smooth horizontal table. If the

particle moves in a circle with speed v, the net force on the particle (directed towards the centre) is (T is the tension in the string)

KCET 2020

Options:

A. T

B. $T-\frac{mv^2}{l}$

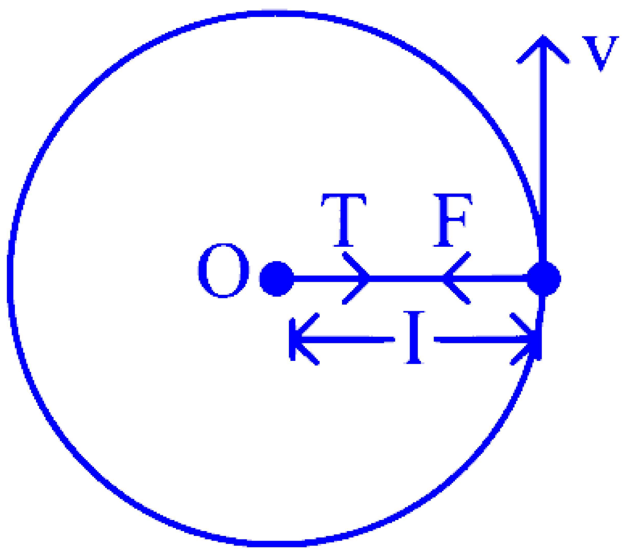
C. $T+\frac{mv^2}{l}$

D. zero

Answer: A

Solution:

Consider a string of length l connected to a particle as shown in figure



As the particle is moving with velocity v in uniform circular motion, so the net force must be equal to the centripetal force, which is provided by the tension in the string.

$$\therefore \text{ Net force } = \text{ Centripetal force } (F_C)$$
$$= \text{ Tension in string } (T)$$
$$\Rightarrow \quad \frac{mv^2}{l} = T$$

Question7

The angle between velocity and acceleration of a particle describing uniform circular motion is

KCET 2017

Options:

A. 180°

B. 90°

C. 45°

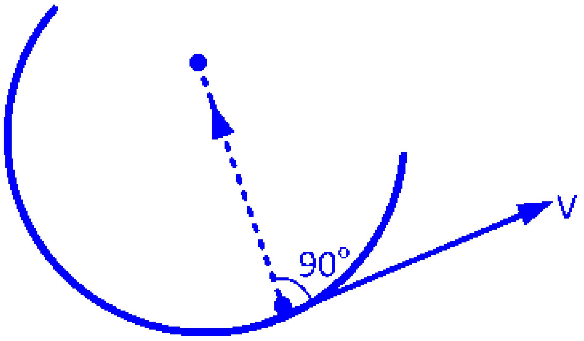
D. 60°

Answer: B

Solution:

When an object follows a circular path at a constant speed, the motion of object is called uniform circular motion.

Although the speed does not vary the particle is accelerating because the velocity changes its direction at every point on circulat track.



The acceleration is centripetal, which is perpendicular to motion at every point and acts along the radius and directed towards the centre of the curved circular path.
