Circular Motion Questions for A-level Physics (ANSWERS)

Basic Concepts

1. What is angular velocity, and how does it relate to angular displacement?

Angular velocity is the rate of change of angular displacement with respect to time.

$\omega = \Delta\theta / \Delta t$

2. Write the formula for linear velocity in terms of angular velocity and radius. Explain each term.

$v = \omega r$

Where: v = linear velocity in ms^{-1}; ω = angular velocity in $rad.s^{-1}$; and r = radius in metres

3. Define centripetal acceleration. In which direction does it act in a circular path?

Centripetal acceleration is the acceleration of an object towards the centre of the circle as it travels in a circular path. $a = v^2 / r$ *or* $a = \omega^2 r$

4. What conditions are necessary for an object to experience centripetal force?

An object must be accelerating in a direction perpendicular to its velocity.

5. If an object moves in a circular path with constant speed, does it have constant velocity? Explain your answer.

Although the speed is constant, the velocity is not. The object is changing direction. If the direction is changing then there must be an acceleration. This acceleration acts towards the centre of the circle.

Calculation Questions

6. A car moves in a circular track of radius 100 m with an angular velocity of 0.50 rad/s. Calculate its linear velocity.

$v = \omega r$

$= 0.50 \times 100$

$= \mathbf{50\ ms^{-1}}$

7. A 2.0 kg object moves with a speed of 5.0 m/s in a circle of radius 4.0 m. Calculate the centripetal force acting on it.

$F = m v^2 / r$

$= 2.0 \times 5^2 \ / \ 4$

$= \mathbf{12.5\ N}$

8. A cyclist rounds a circular path of radius 50 m at a speed of 10 m/s. Find the centripetal acceleration.

$A = v^2 / r$

$= 10^2 / 50$

$= \mathbf{2.0\ ms^{-2}}$

9. A ball tied to a string is swung in a circle of radius 1.5 m, with a period of 2.0 s. Calculate the angular velocity of the ball.

$\omega = \Delta\theta / \Delta t$

$= 2\ \pi / 2.0$

$= \mathbf{3.14\ rad.s^{-1}}$

10. An object moving in a circular path has an angular displacement of π/4 radians in 2.0 seconds. Calculate its angular velocity.

$\omega = \Delta\theta / \Delta t$

$= \pi/4 \ / 2$

$= \mathbf{0.39\ rad.s^{-1}}$

11. A 10 kg object is moving in a circle of radius 2.0 m with an angular velocity of 3.0 rad/s. Calculate the centripetal force acting on it.

$F = m \omega^2 r$

$= 10 \times 3^2 \times 2$

$=$ ***180 N***

12. An object in circular motion has a centripetal acceleration of 8.0 m/s² and is moving in a circle of radius 4.0 m. Calculate the object's speed.

$a = v^2 / r$

$8 = v^2 / 4$

$V = \sqrt{8 \times 4}$ $=$ ***5.7 ms^{-1}***

13. A satellite orbits Earth in a circular path with a radius of 6.7×10^6 m and a period of 5400 s. Calculate its angular velocity.

$\omega = \Delta\theta / \Delta t$

$= 2 \pi / 5400$

$=$ ***1.2 x 10^{-3} rad.s^{-1}***

14. If a car moves around a circular track with a radius of 20 m at a constant speed of 15 m/s, calculate the centripetal force required if the car's mass is 1200 kg.

$F = m v^2 / r$

$= 1200 \times 15^2 / 20$

$=$ ***13500 N***

15. A rotating disc completes 120 revolutions per minute (rpm). Calculate its angular velocity in rad/s.

$\omega = 120 \times 2\pi / 60$

$=$ ***12.6 rad.s^{-1}***

16. An object moves with a constant speed in a circular path and completes one revolution every 10 seconds. If the radius of the path is 5.0 m, calculate the linear velocity.

$v = \omega r$

$= \frac{2\pi}{10} \times 5.0$

$= \mathbf{3.14\ ms^{-1}}$

17. A 1.5 kg object tied to a string is swung in a horizontal circle of radius 2.0 m, with a speed of 4.0 m/s. Calculate the tension in the string, assuming it provides the necessary centripetal force.

$T = F = m v^2 / r$

$= 1.5 \times 4^2 / 2$

$= \mathbf{12\ N}$

18. A roller coaster moves in a vertical loop of radius 15 m. What is the minimum speed it must have at the top of the loop to avoid falling?

$a = g = v^2 / r$

$9.81 = v^2 / 15$

$15 \times 9.81 = v^2$ $v = \mathbf{12\ ms^{-1}}$

19. If a car moves around a circular track with a radius of 20 m at a constant speed of 15 m/s, calculate the centripetal force required if the car's mass is| 1200 kg.

$F = m v^2 / r$

$= 1200 \times 15^2 / 20$

$= \mathbf{13{,}500\ N}$

20. A pendulum of length 20cm swings in a circular arc. At the lowest point of its swing, the tension in the string is 50 N, and the mass of the pendulum bob is 2.0 kg. Determine the speed of the bob at this point.

Tension = weight + centripetal force required

$T = m g + m v^2 / r$

$50 = (2 \times 9.81) + (2 \times v^2 / 0.20)$

$30.38 = 2 v^2 / 0.20$

$\sqrt{\frac{30.38}{10}} = v$ $= \mathbf{1.7 ms^{-1}}$