Circular Motion Questions – OCR A Level Physics

Praneel Physics

1. State the unit of angular velocity. **(P)**

Working and Answer:

Radian per second (rad/s).

2. Define centripetal force. **(P)**

Working and Answer:

The resultant force acting towards the centre of a circular path that causes centripetal acceleration.

3. Write the equation that links linear speed, radius, and angular velocity. **(P)**

Working and Answer:

$$v = \omega r$$

4. What is meant by a radian? **(P)**

Working and Answer:

A radian is the angle subtended at the centre of a circle by an arc equal in length to the radius.

5. State the formula for centripetal acceleration. **(P)**

Working and Answer:

$$a = \frac{v^2}{r} \quad \text{or} \quad a = \omega^2 r$$

6. Describe the direction of velocity and acceleration in circular motion. **(PP)**

Working and Answer:

Velocity is tangential to the circle; acceleration is directed towards the centre (centripetal).

7. Explain why an object in circular motion is accelerating even if its speed is constant. **(PP)**

Working and Answer:

Its direction is constantly changing, so its velocity is changing, hence it's accelerating.

8. Explain why an object moving in a circle at constant speed is not in equilibrium. **(PP)**

Working and Answer:

There is a net force (centripetal force) acting towards the centre, so Newton's First Law is not satisfied.

9. What provides the centripetal force for a car going around a flat bend? **(PP)**

Working and Answer:

The friction between the tyres and the road.

10. A ball of mass $0.5\,\text{kg}$ is swung in a horizontal circle of radius $1.2\,\text{m}$ at $3.0\,\text{ms}^{-1}$. Calculate the centripetal force. **(PPP)**

Working and Answer:

$$F = \frac{mv^2}{r} = \frac{0.5 \times 3.0^2}{1.2} = 3.75\,\text{N}$$

11. Calculate the angular velocity of an object completing one full revolution every 2 seconds. **(PPP)**

Working and Answer:

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi \,\text{rad/s}$$

12. A washing machine drum spins at 1200 rpm. Calculate its angular velocity in rad/s. **(PPP)**

> *Working and Answer:*
>
> $$\omega = \frac{2\pi \times 1200}{60} = 125.7\,\text{rad/s}$$

13. What is the linear speed of a point on the rim of a wheel of radius 0.3 m rotating at 10 rad/s? **(PPP)**

> *Working and Answer:*
>
> $$v = \omega r = 10 \times 0.3 = 3.0\,\text{ms}^{-1}$$

14. Explain the role of banking in reducing the reliance on friction for centripetal force in curved roads. **(PPPP)**

Working and Answer:

Banking introduces a horizontal component of the normal force, reducing the need for friction to provide all of the centripetal force.

15. A mass is attached to a string and whirled in a vertical circle. Explain how the tension in the string varies. **(PPPP)**

Working and Answer:

Tension is greatest at the bottom (gravity and centripetal force both act inward), and least at the top (centripetal force minus weight).

16. A car of mass $1000\,\text{kg}$ rounds a bend of radius $50\,\text{m}$ at $15\,\text{ms}^{-1}$. Calculate the required centripetal force. **(PPPP)**

Working and Answer:

$$F = \frac{mv^2}{r} = \frac{1000 \times 15^2}{50} = 4500\,\text{N}$$

17. Explain why an astronaut in circular orbit experiences apparent weightlessness. **(PPPP)**

Working and Answer:

They are in free fall, experiencing only centripetal acceleration; there is no normal contact force acting on them.

18. A satellite orbits Earth in a circular orbit of radius 7.0×10^6 m. Calculate its speed if it completes one orbit in 6000 s. **(PPPPP)**

Working and Answer:

$$v = \frac{2\pi r}{T} = \frac{2\pi \times 7.0 \times 10^6}{6000} \approx 7330 \, \text{ms}^{-1}$$

19. A mass of 0.25 kg moves in a circle of radius 0.5 m with angular speed 6 rad/s. Calculate the centripetal force. **(PPPPP)**

Working and Answer:

$$F = m\omega^2 r = 0.25 \times 6^2 \times 0.5 = 4.5 \, \text{N}$$

20. Derive the expression for centripetal force from Newton's Second Law and the definition of acceleration. **(PPPPP)**

Working and Answer:

From $a = \frac{v^2}{r}$ and $F = ma$, we get:

$$F = m\frac{v^2}{r}$$

21. A small object is in vertical circular motion. At the top of the circle, tension is zero. Derive the minimum speed required at the top. **(PPPPP)**

Working and Answer:

$$\frac{mv^2}{r} = mg \Rightarrow v^2 = gr \Rightarrow v = \sqrt{gr}$$