

circular motion practice problems with answers

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Introduction

When students first encounter the concept of circular motion, many find it challenging to grasp how objects move in a circle and how the forces involved differ from linear motion. Mastery of this topic is essential for success in physics courses, engineering studies, and even everyday problem solving. One of the most effective ways to build confidence and deepen understanding is through targeted practice problems with clear, step by step answers. This article presents a comprehensive set of circular motion practice problems, complete solutions, and valuable study tips—all designed to help learners of any level turn conceptual confusion into mastery.

Understanding Circular Motion

Key Concepts

Circular motion occurs when an object travels along a circular path. Unlike linear motion, where velocity and acceleration are straightforward, circular motion introduces unique elements such as **angular velocity**, **radius**, and **centripetal acceleration**. Key terms include:

- Radius (r) – Distance from the center of the circle to the moving object.
- Circumference (C) – Total distance around the circle, calculated as $C = 2\pi r$.
- Tangential speed (v) – Speed along the circular path; related to angular speed by $v = r\omega$.
- Angular velocity (ω) – Rate of change of angular displacement; measured in radians per second.
- Period (T) – Time for one full revolution; $T = 1/f$ where f is frequency.
- Centripetal force (F_c) – Force that keeps the object moving in a circle; $F_c = mv^2/r = m\omega^2 r$.

Mathematical Relationships

When solving circular motion problems, students often rely on the following core equations:

- Angular velocity to tangential speed: $v = r\omega$
- Period to angular velocity: $\omega = 2\pi/T$
- Centripetal acceleration: $a_c = v^2/r = \omega^2 r$
- Centripetal force: $F_c = m a_c = m v^2/r = m \omega^2 r$
- Frequency to period: $f = 1/T$

Mastering these relationships is the foundation for tackling more complex scenarios, such as varying radii, non uniform motion, or additional forces acting on the system.

Why Practice Problems Matter

Conceptual understanding alone is insufficient for physics proficiency. Practice problems force students to apply formulas, recognize patterns, and troubleshoot errors. When solutions are provided, learners can verify their reasoning, learn alternative methods, and build confidence. The practice problems below cover a spectrum of difficulty levels, ensuring that beginners and advanced students alike benefit.

Circular Motion Practice Problems with Answers

Below are ten carefully chosen circular motion practice problems. Each problem is followed by a concise solution that explains the reasoning and highlights common pitfalls. Use these to test your knowledge and refine your problem solving skills.

Solution: First, compute centripetal acceleration: $a_c = v^2/r = (20^2)/100 = 400/100 = 4 \text{ m/s}^2$ Next, centripetal force: $F_c = m a_c = 1500 \times 4 = 6000 \text{ N}$ The car requires a 6000 Newton inward force to maintain its circular path.

Problem 2: A satellite orbits Earth at a radius of $6.8 \times 10^6 \text{ m}$ (Earth's radius plus 300 km altitude). If the satellite's orbital speed is $7.8 \times 10^3 \text{ m/s}$, calculate its angular velocity and orbital period.

Solution: Angular velocity: $\omega = v/r = (7.8 \times 10^3) / (6.8 \times 10^6) = 1.15 \times 10^{-3} \text{ rad/s}$ Period: $T = 2\pi / \omega = 2\pi / (1.15 \times 10^{-3}) = 5450 \text{ s} = 91 \text{ minutes}$ The satellite completes a full orbit roughly every 91 minutes.

Problem 3: A roller coaster car of mass 800 kg moves at 15 m/s around a vertical loop of radius 30 m. What is the centripetal force at the bottom of the loop, and how does it compare to the car's weight?

Solution: Centripetal force: $F_c = m v^2/r = 800 \times (15^2)/30 = 800 \times 225/30 = 800 \times 7.5 = 6000 \text{ N}$ Weight: $W = m g = 800 \times 9.81 = 7848 \text{ N}$ At the bottom, the track must provide an upward force equal to $F_c + W = 6000 + 7848 = 13,848 \text{ N}$ to keep the car moving in a circle, which is larger than the car's weight alone.

Problem 4: A Ferris wheel has a radius of 25 m. If a passenger experiences a centripetal acceleration of 1.5 m/s^2 at the bottom, what is the wheel's angular speed?

Solution: Use $a_c = \omega^2 r$: $1.5 = \omega^2 \times 25$ $\omega = \sqrt{1.5/25} = \sqrt{0.06} = 0.245 \text{ rad/s}$ The wheel rotates at about 0.245 /rad/s.

Problem 5: A ball tied to a string is whirled in a horizontal circle of radius 0.5 m at a speed of 12 m/s. If the string's tension is 30 N, what is the mass of the ball?

Solution: Centripetal force equals tension: $F_c = T = 30 \text{ N} = m v^2/r$ Solve for m: $m = (T r)/v^2 = (30 \times 0.5) / 12^2 = 15 / 144 = 0.104 \text{ kg}$ The ball's mass is approximately 104 g.

Problem 6: A cyclist accelerates from rest to 8 m/s while riding around a circular track of radius 40 m over a distance of 200 m. Assuming uniform circular motion after reaching 8 m/s, calculate the time spent accelerating and the time spent traveling at constant speed.

Solution: The distance to accelerate is part of the 200 m arcs = $r\theta$. Since acceleration is uniform, average speed during acceleration is $(0 + 8)/2 = 4 \text{ m/s}$ Thus, time accelerating: $t_a = s_a / 4$. However, we need s_a . The total arc length is 200 m, so $s_a + s_c = 200$. The time at constant speed corresponds to the remaining angle: $s_c = r\theta_c$. With uniform acceleration, the distance covered during acceleration equals $s_{\text{accel}} = (1/2) a t_a^2$ but we can also express it as $s_{\text{accel}} = (1/2)(v_f + v_i)t_a = 4 t_a$. Without additional data (like acceleration magnitude), we can only provide the relationship: $t_a = s_{\text{accel}} / 4$ and $t_{\text{const}} = (200 - s_{\text{accel}}) / 8$. In practice, the problem would supply the acceleration or the time to reach 8 m/s. Thus, this problem highlights the importance of complete data for accurate calculations.

Problem 7: A spinning merry go round has a radius of 3 m. A child on the edge experiences a centripetal acceleration of 2 m/s^2 . How many revolutions per minute (RPM) does the merry go round make?

Solution: First, find angular velocity: $a_c = \omega^2 r$ $2 = \omega^2 \times 3$ $\omega = \sqrt{2/3} = 0.816 \text{ rad/s}$ Convert to revolutions per second: $f = \omega / (2\pi) = 0.816 / 6.283 = 0.13 \text{ rev/s}$ Convert to RPM: $\text{RPM} = f \times 60 = 0.13 \times 60 = 7.8 \text{ RPM}$ The merry go round spins at about 8 revolutions per minute.

Problem 8: A yo yo unwinds as it spins. The string unwinds at a linear speed of 2 m/s. If the yo yo's radius is 0.15 m,

what is its angular speed in revolutions per second?

Solution: Angular speed: $\omega = 2\pi f$ Convert to revolutions per second: $f = \frac{\omega}{2\pi}$ "H 13

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