

Rotational Motion Worksheet Answer Key

KEY

Advanced Physics Practice Problems

Unit 11: Rotational Kinematics and Centripetal Motion

Circular motion can involve rotation and/or revolution. Rotation occurs when the object spins about an internal axis. Revolution occurs when the axis lies outside of the object. Some objects do both at the same time! The time it takes for an object to make one rotation or one revolution is called its period.

Linear motion involves concepts we studied last semester such as displacement (Δx) and velocity ($\Delta x/\Delta t$). Circular motions involve changing an angle ($\Delta\theta$) and angular velocity (ω) which is how much this angle changes with respect to time: ($\Delta\theta/\Delta t$). Additionally, a rotating or revolving object also can move linearly or tangentially. The displacement is an arc around the circumference ($\Delta x = 2\pi r$); the velocity [called tangential velocity (v_t)] is this displacement over time. It is called tangential as the object's velocity is tangential to the arc.



As seen from the North Pole, the earth spins CCW once in 24 hours (actually it is slightly less).

1. (a) What is the $\Delta\theta$ in degrees and radians that the earth moves in 1 hour? (answer = 15 degrees or 0.262 radians)

$$\frac{360^\circ}{24 \text{ hrs}} = 15 \text{ deg/hr} \quad \frac{2\pi \text{ rad}}{24 \text{ hrs}} = 0.262 \frac{\text{rad}}{\text{hr}}$$

- (b) What is the Earth's angular velocity (ω) in rpm, degrees per hour, and radians per second? (answers = 6.94×10^{-4} rpm; 15 deg/hr; 7.27×10^{-5} rad/sec)

$$\begin{aligned} \text{rpm: } \frac{1 \text{ rot}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{60 \text{ min}} &= 6.94 \times 10^{-4} \text{ rpm} \\ \text{deg/hr: } 15^\circ/\text{hr} & \text{ (above answer)} \\ \text{rad/sec: } \frac{0.262 \text{ rad}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} &= 7.28 \times 10^{-5} \text{ rad/s} \end{aligned}$$

- (c) If the earth's radius is about 6.4×10^6 meters, what tangential velocity (m/s) does an object have at the equator? (answer = 465.4 m/s) or 466 depending on rounding

$$\begin{aligned} \text{Several methods: } v &= r\omega = \frac{2\pi(6.4 \times 10^6 \text{ m})}{24 \text{ hrs} \times 3600 \text{ sec}} = 465.4 \text{ m/s} \\ &= 6.4 \times 10^6 \text{ m} (7.28 \times 10^{-5} \text{ rad/s}) \\ &= 465.9 \text{ m/s} \end{aligned}$$

2. A traditional watch has three hands: an hour hand, a minute hand, and a second hand.

Determine the angular velocity (ω) in radians per second for each hand.

(a) hour hand (answer = 1.45×10^{-4} rad/s): hour hand goes around once every 12 hr

$$\frac{1 \text{ rot}}{12 \text{ hrs}} \times \frac{2\pi \text{ rad}}{1 \text{ rot}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} = 1.45 \times 10^{-4} \text{ rad/s}$$

(b) minute hand (answer = 1.74×10^{-3} rad/s): minute hand goes around once/hr

$$\frac{1 \text{ rot}}{1 \text{ hr}} \times \frac{2\pi \text{ rad}}{1 \text{ rot}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = 1.74 \times 10^{-3} \text{ rad/sec}$$

(c) second hand (answer = 1.05×10^{-1} rad/s)

$$\frac{1 \text{ rot}}{60 \text{ sec}} \times \frac{2\pi \text{ rad}}{1 \text{ rot}} = 1.05 \times 10^{-1} \text{ rad/sec}$$



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Rotational motion worksheet answer key is a crucial resource for students and educators alike, providing a means to verify understanding of concepts related to rotational motion in physics. Rotational motion, a fundamental aspect of mechanics, deals with the movement of objects around a fixed axis. This article will explore the key concepts of rotational motion, outline typical problems found in worksheets, and provide a comprehensive answer key to facilitate learning and comprehension.

Understanding Rotational Motion

Rotational motion is characterized by the following essential concepts:

1. Angular Displacement

Angular displacement refers to the angle through which an object has rotated about a specific axis. It is typically measured in radians and is a vector quantity.

- Formula: $\theta = s/r$
- Where θ is the angular displacement, s is the arc length, and r is the radius of the circular path.

2. Angular Velocity

Angular velocity is the rate of change of angular displacement with respect to time. It determines how fast an object is rotating.

- Formula: $\omega = \Delta\theta/\Delta t$
- Where ω is the angular velocity, $\Delta\theta$ is the change in angular displacement, and Δt is the change in time.

3. Angular Acceleration

Angular acceleration is the rate of change of angular velocity. It indicates how quickly an object is speeding up or slowing down its rotation.

- Formula: $\alpha = \Delta\omega/\Delta t$
- Where α is the angular acceleration, $\Delta\omega$ is the change in angular velocity, and Δt is the change in time.

4. Moment of Inertia

The moment of inertia is a measure of an object's resistance to changes in its rotational motion. It depends on the mass distribution relative to the axis of rotation.

- Formula: $I = \Sigma(mr^2)$
- Where I is the moment of inertia, m is the mass of an individual particle, and r is the distance from the axis of rotation.

5. Torque

Torque is a measure of the force that can cause an object to rotate about an axis. It is the rotational equivalent of linear force.

- Formula: $\tau = rF\sin(\theta)$
- Where τ is torque, r is the distance from the axis of rotation to the point where the force is applied, F is the applied force, and θ is the angle between the force vector and the lever arm.

6. Rotational Kinematics

Similar to linear kinematics, rotational kinematics deals with the motion of rotating objects. Key equations include:

1. $\omega = \omega_0 + \alpha t$
2. $\theta = \omega_0 t + 0.5 \alpha t^2$
3. $\omega^2 = \omega_0^2 + 2 \alpha \theta$

Where ω_0 is the initial angular velocity, t is the time, and θ is the angular displacement.

Typical Problems in Rotational Motion Worksheets

Rotational motion worksheets often contain problems that test students' understanding and application of the concepts outlined above. Here are some common types of problems:

1. Calculating Angular Displacement

Problems may ask students to determine the angular displacement of an object rotating at a constant angular velocity over a specified time.

2. Determining Angular Velocity and Acceleration

Worksheets may include scenarios where students must calculate angular velocity and angular acceleration given specific parameters.

3. Moment of Inertia Calculations

Students may be tasked with calculating the moment of inertia for various shapes, such as disks, spheres, and rods, using their respective formulas.

4. Torque Applications

Problems might involve calculating the torque required to rotate an object, given the force applied and the distance from the axis of rotation.

5. Rotational Dynamics

Students may encounter problems that combine concepts of torque, moment of inertia, and angular acceleration to determine the resulting motion of rotating objects.

Answer Key for Rotational Motion Worksheet

Below is a sample answer key for a typical rotational motion worksheet. The problems are hypothetical and designed to illustrate common types of questions.

Problem 1: Angular Displacement

Question: A wheel makes 5 complete revolutions. What is the angular displacement in radians?

- Answer:
- Angular displacement (θ) = 5 revolutions \times 2π radians/revolution
- $\theta = 10\pi$ radians

Problem 2: Angular Velocity

Question: A wheel rotates at a constant rate of 120 degrees per second. Convert this to radians per second.

- Answer:
- $\omega = 120 \text{ degrees/second} \times (\pi \text{ radians}/180 \text{ degrees})$
- $\omega = 2.094 \text{ radians/second}$

Problem 3: Moment of Inertia

Question: Calculate the moment of inertia of a solid disk of mass 10 kg and radius 0.5 m.

- Answer:
- $I = (1/2)mr^2 = (1/2)(10 \text{ kg})(0.5 \text{ m})^2$
- $I = (1/2)(10)(0.25) = 1.25 \text{ kg}\cdot\text{m}^2$

Problem 4: Torque Calculation

Question: A force of 20 N is applied at a distance of 0.3 m from the pivot point at an angle of 90 degrees. Calculate the torque.

- Answer:
- $\tau = rF\sin(\theta) = (0.3 \text{ m})(20 \text{ N})(\sin(90 \text{ degrees}))$
- $\tau = (0.3)(20)(1) = 6 \text{ N}\cdot\text{m}$

Problem 5: Rotational Dynamics

Question: A solid sphere of mass 5 kg and radius 0.2 m is rolling down an incline. Calculate its angular acceleration if a torque of 2 N·m is applied.

- Answer:
- Moment of inertia for a solid sphere: $I = (2/5)mr^2 = (2/5)(5 \text{ kg})(0.2 \text{ m})^2$
- $I = (2/5)(5)(0.04) = 0.08 \text{ kg}\cdot\text{m}^2$
- $\alpha = \tau/I = 2 \text{ N}\cdot\text{m} / 0.08 \text{ kg}\cdot\text{m}^2 = 25 \text{ rad/s}^2$

Conclusion

The rotational motion worksheet answer key serves as an educational tool that aids students in grasping the principles of rotational motion. By engaging with various types of problems and utilizing the provided answer key, learners can deepen their understanding of fundamental physics concepts. Mastery of rotational motion not only enhances problem-solving skills but also lays the groundwork for further studies in mechanics and engineering. As students continue to practice and apply these concepts, they will develop a sound comprehension that is essential for success in advanced physics topics.

Frequently Asked Questions

What is a rotational motion worksheet?

A rotational motion worksheet is an educational resource that contains problems and exercises related to the concepts of rotational motion, such as angular velocity, torque, and moment of inertia.

What topics are typically covered in a rotational motion worksheet?

Topics usually include angular displacement, angular speed, rotational dynamics, conservation of angular momentum, and applications of rotational motion in real-world scenarios.

How can I find answer keys for rotational motion worksheets?

Answer keys for rotational motion worksheets can often be found in teacher's editions of textbooks, educational websites, or through educational resource platforms that provide solutions for various worksheets.

Why is understanding rotational motion important in physics?

Understanding rotational motion is crucial in physics as it helps explain the behavior of rotating objects, which is essential in various fields including engineering, astronomy, and mechanics.

What are some common formulas used in rotational motion problems?

Common formulas include: 1) Angular velocity ($\omega = \theta/t$), 2) Torque ($\tau = r \times F$), 3) Moment of inertia ($I = \sum mr^2$), and 4) Angular momentum ($L = I\omega$).

Are there online resources available for practicing rotational motion problems?

Yes, many educational websites and platforms offer interactive problems, video tutorials, and practice worksheets specifically focusing on rotational motion.

What skills can students develop by working on rotational motion worksheets?

Students can develop problem-solving skills, analytical thinking, and a deeper understanding of physical laws governing motion, which are applicable in advanced studies and practical applications.

Can rotational motion worksheets be used for group study?

Yes, rotational motion worksheets can be effectively used for group study, allowing students to collaborate, discuss different approaches, and enhance their understanding of key concepts through teamwork.

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