

Holt Physics

Problem 8C**NEWTON'S SECOND LAW FOR ROTATION****PROBLEM**

The giant sequoia General Sherman in California has a mass of about 2.00×10^6 kg, making it the most massive tree in the world. Its height of 83.0 m is also impressive. Imagine a uniform bar with the same mass and length as the tree. If this bar is rotated about an axis that is perpendicular to and passes through the bar's midpoint, how large an angular acceleration would result from a torque of 4.60×10^7 N·m? (Note: Assume the bar is thin.)

SOLUTION

Given: $M = 2.00 \times 10^6$ kg
 $L = 83.0$ m
 $\tau = 4.60 \times 10^7$ N·m

Unknown: $\alpha = ?$

Calculate the bar's moment of inertia using the formula for a thin rod with the axis of rotation at its center.

$$I = \frac{1}{12} ML^2 = \frac{1}{12} (2.00 \times 10^6 \text{ kg})(83.0 \text{ m})^2 = 1.15 \times 10^9 \text{ kg}\cdot\text{m}^2$$

Now use the equation for Newton's second law for rotating objects. Rearrange the equation to solve for angular acceleration.

$$\tau = I\alpha$$

$$\alpha = \frac{\tau}{I} = \frac{(4.60 \times 10^7 \text{ N}\cdot\text{m})}{(1.15 \times 10^9 \text{ kg}\cdot\text{m}^2)} = \boxed{4.00 \times 10^{-2} \text{ rad/s}^2}$$

ADDITIONAL PRACTICE

- One of the largest Ferris wheels currently in existence is in Yokohama, Japan. The wheel has a radius of 50.8 m and a mass of 1.20×10^6 kg. If a torque of 1.0×10^8 N·m is needed to turn the wheel from a state of rest, what would the wheel's angular acceleration be? Treat the wheel as a thin hoop.
- In 1992, Jacky Vrancken from Belgium attained a speed of more than 250 km/h on just the back wheel of a motorcycle. Assume that all of the back wheel's mass is located at its outer edge. If the wheel has a mass of 22 kg and a radius of 0.36 m, what is the wheel's angular acceleration when a torque of 5.7 N·m acts on the wheel?
- In 1995, a fully functional pencil with a mass of 24 kg and a length of 2.74 m was made. Suppose this pencil is suspended at its midpoint and a force of 1.8 N is applied perpendicular to its end, causing it to rotate. What is the angular acceleration of the pencil?

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Ying Liu



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Table of Contents Holt Mcgonal Physics Problems Manual Problem

1. Understanding the eBook Holt Mcgonal Physics Problems Manual Problem
 - The Rise of Digital Reading Holt Mcgonal Physics Problems Manual Problem
 - Advantages of eBooks Over Traditional Books
2. Identifying Holt Mcgonal Physics Problems Manual Problem
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Holt Mcgonal Physics Problems Manual Problem
 - User-Friendly Interface
4. Exploring eBook Recommendations from Holt Mcgonal Physics Problems Manual Problem
 - Personalized Recommendations
 - Holt Mcgonal Physics Problems Manual Problem User Reviews and Ratings
 - Holt Mcgonal Physics Problems Manual Problem and Bestseller Lists
5. Accessing Holt Mcgonal Physics Problems Manual Problem Free and Paid eBooks
 - Holt Mcgonal Physics Problems Manual Problem Public Domain eBooks
 - Holt Mcgonal Physics Problems Manual Problem eBook Subscription Services
 - Holt Mcgonal Physics Problems Manual Problem Budget-Friendly Options

6. Navigating Holt Mcgonal Physics Problems Manual Problem eBook Formats
 - ePub, PDF, MOBI, and More
 - Holt Mcgonal Physics Problems Manual Problem Compatibility with Devices
 - Holt Mcgonal Physics Problems Manual Problem Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Holt Mcgonal Physics Problems Manual Problem
 - Highlighting and Note-Taking Holt Mcgonal Physics Problems Manual Problem
 - Interactive Elements Holt Mcgonal Physics Problems Manual Problem
8. Staying Engaged with Holt Mcgonal Physics Problems Manual Problem
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Holt Mcgonal Physics Problems Manual Problem
9. Balancing eBooks and Physical Books Holt Mcgonal Physics Problems Manual Problem
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Holt Mcgonal Physics Problems Manual Problem
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Holt Mcgonal Physics Problems Manual Problem
 - Setting Reading Goals Holt Mcgonal Physics Problems Manual Problem
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Holt Mcgonal Physics Problems Manual Problem
 - Fact-Checking eBook Content of Holt Mcgonal Physics Problems Manual Problem
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

-
- Interactive and Gamified eBooks

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