Unit 12 *Homework Problems*

Learning Goals:

F.12a Relate translational kinematics quantities to rotational kinematics quantities.

F.12b Calculate, or qualitatively compare, rotational inertia for a variety of shapes and explain how it will affect an object's rotation.

A.12 Apply rotational kinematics equations to solve for an unknown or model and interpret a rotational position vs. time graph.

12-1) **Disk Rotation:** In this problem, you will be analyzing the motion of a rotating aluminum disk. This motion is shown in the digital movie DSON014.mov. A small spool is connected to the aluminum disk by an axle that is free to rotate in an almost frictionless manner inside of a bearing. A string is wrapped around the spool and a weight, which is attached to the string, is allowed to fall.

(a) Use the Logger Pro software to gather data for the rotational position of some recognizable point on the disk as a function of time. Create a graph of rotational position (*i.e.*, angle) vs. time. Is the rotational velocity constant or changing? Is the rotational acceleration constant or changing? What about the rotational position vs. time graph allows you to answer this question.

(b) If you concluded that the rotational acceleration is constant, then determine what its value is in rad/s/s. Explain how you arrived at your conclusions, showing relevant data and graphs.

(c) What is the equation that describes the angle through which the disk has moved as a function of time? Explain how you determined this equation.

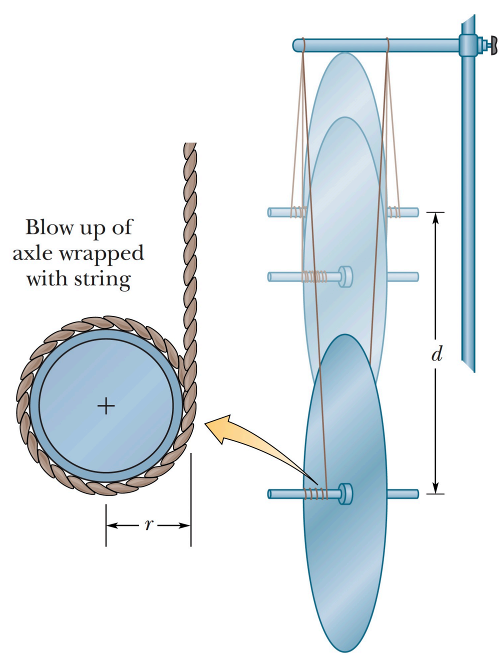
(d) What is the equation that describes the rotational velocity of the disk as a function of time? Explain how you derived this equation.

12-2) **The YO-YO:** A quantitative yo-yo consists of a disk (or other shape) fixed to an axle that has two strings wrapped around it. As the axle rolls off the strings, the disk and the axle fall as shown in the diagram on the right.

(a) If the disk has fallen through a vertical distance of $\Delta y = d = 30$ cm and the radius of the string and axle is given by $r = 5.0$ mm, how many revolutions has the disk gone through?

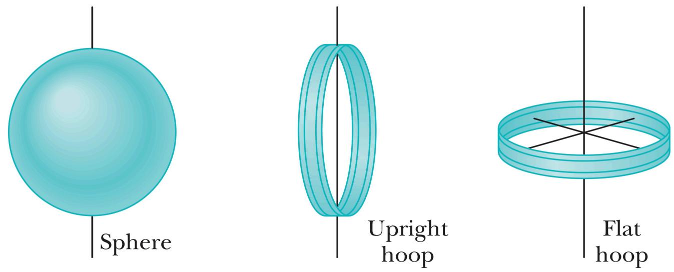
(b) If the disk is rotating faster and faster with a constant rotational acceleration and takes 25 s to fall through the distance d from rest, what is the magnitude of its rotational acceleration α?

(c) What is the magnitude of its rotational velocity ω after the 25 s have elapsed? **Hint**: Use the rotational kinematic equations.

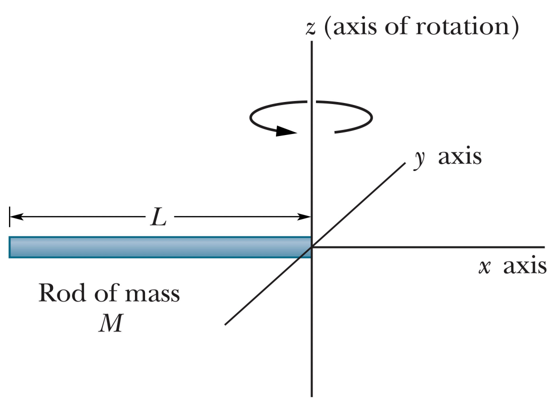


12-3) **Using A Torque To Stop A Motion:** Carman pulls on a rod mounted on a frictionless pivot with a force of 78.2 N at a distance of 49 cm from the pivot. Carlos is trying to stop the rod from undergoing a rotational acceleration by exerting a force in the opposite direction to the one Carman exerts. Carlos' force is applied 85 cm from the pivot and is perpendicular to the rod. What is the magnitude of his "balancing" force?

12-4) **Comparing Rotational Inertias**: If all three of the objects shown on the next page have the same radius and mass, which one has the most rotational inertia about its indicated axis of rotation? Which one has the least rotational inertia? Explain the reasons for your answer. **Hint**: Consider which one has its mass distributed farthest from the axis of rotation.



12-5) **Summing Up To Estimate Rotational Inertia:** By performing an integration it can be shown that the general equation for the rotational inertia of a thin rod of length L and mass M about an axis through one end of the rod which is perpendicular to its length is given by $I = \frac{1}{3}ML^2$ (see the table on page 415 of your Activity Guide). Consider a rod of length 0.50 m that has a mass of 1.2 kg.



(a) Calculate the theoretical value of the rotational inertia.

(b) Estimate the rotational inertia of the rod by breaking it into 50 small point objects, each having a mass of $M/50$, with the first point object being 0.005m from the axis of rotation, the second point object being 0.015 m from the axis of rotation, and so on. Use a spreadsheet to do your estimated calculations of the rotational inertia of the rod.

(c) Compare the theoretically calculated value with the estimated value. Are they similar?

12-6) Problem 12.9.1 from the Activity Guide.