Zhejiang University

Department of Physics

General Physics (H) Problem Set #4

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1. Three identical thin rods, each of length $L$ and mass $m$, are welded perpendicular to each other, as shown in Figure P10.28. The entire setup is rotated about an axis that passes through the end of one rod and is parallel to another. Determine the moment of inertia of this arrangement.

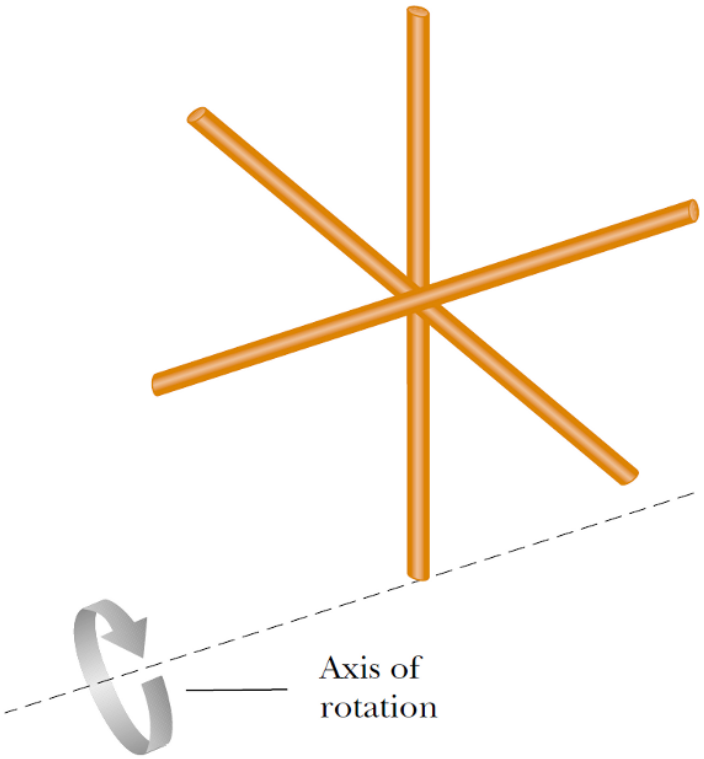


***Figure P10.28***

2. This problem describes one experimental method of determining the moment of inertia of an irregularly shaped object such as the payload for a satellite. Figure P10.47 shows a mass $m$ suspended by a cord wound around a spool of radius $r$, forming part of a turntable supporting the object. When the mass is released from rest, it descends through a distance $h$, acquiring a speed $v$. Show that the moment of inertia $I$ of the equipment (including the turntable) is $mr^2(2gh/v^2 - 1)$.

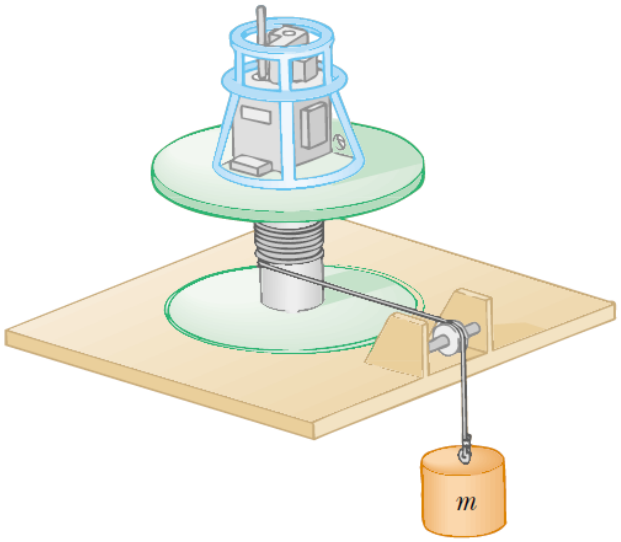


***Figure P10.47***

3. (a) What is the rotational energy of the Earth about its spin axis? The radius of the Earth is 6 370 km, and its mass is $5.98 \times 10^{24}$ kg. Treat the Earth as a sphere of moment of inertia $\frac{2}{5}MR^2$. (b) The rotational energy of the Earth is decreasing steadily because of tidal friction. Estimate the change in one day, given that the rotational period increases by about 10 $\mu$s each year.

4. Three objects of uniform density—a solid sphere, a solid cylinder, and a hollow cylinder—are placed at the top of an incline (Fig. Q11.12). If they all are released from rest at the same elevation and roll without slipping, which object reaches the bottom first? Which reaches it last? You should try this at home and note that the result is independent of the masses and the radii of the objects.

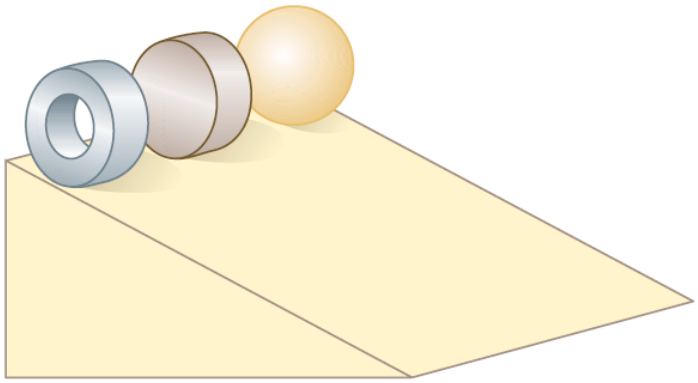

***Figure Q11.12*** Which object wins the race?

5. A bicycle wheel has a diameter of 64.0 cm and a mass of 1.80 kg. Assume that the wheel is a hoop with all of its mass concentrated on the outside radius. The bicycle is placed on a stationary stand on rollers, and a resistive force of 120 N is applied tangent to the rim of the tire. (a) What force must be applied by a chain passing over a 9.00-cm-diameter sprocket if the wheel is to attain an acceleration of 4.50 rad/s$^2$? (b) What force is required if the chain shifts to a 5.60-cm-diameter sprocket?

6. A student claims that she has found a vector $\mathbf{A}$ such that $(2\mathbf{i} - 3\mathbf{j} + 4\mathbf{k}) \times \mathbf{A} = (4\mathbf{i} + 3\mathbf{j} - \mathbf{k})$. Do you believe this claim? Explain.