Rotation – Set 2

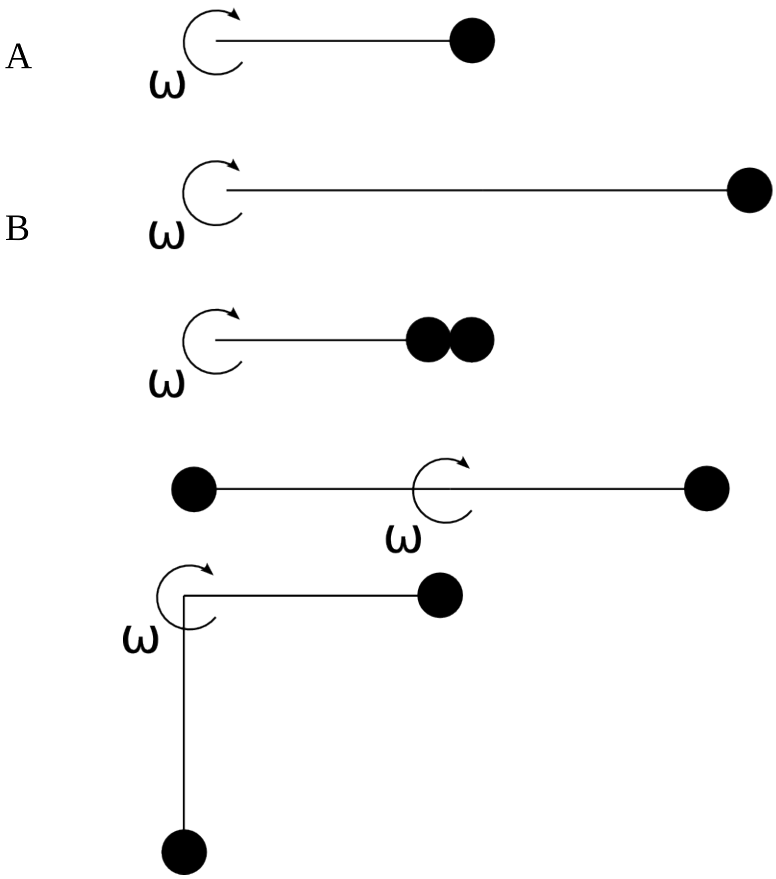
Name: ______________________ Problems Solved __/ 8

Circular disks A and B have the same mass and thickness, but the density of disk A is greater than the density of disk B. Which has the greater moment of inertia? **Explain your reasoning.**

Two bars have the same mass, but one is shorter than the other. Which has a larger moment of inertia? **Explain your reasoning.**

Below are the cross sections of five solids with identical masses. They are allowed to rotate about an axis through their centers perpendicular to the plane of the page. They all have equal widths at their widest points. Without looking them up or doing any calculations, rank the objects in order of moment of inertia, least to most. **Explain your reasoning**.

Below are several objects. Each circle is a point mass, and each point has the same mass. The connecting rods are massless. Rank them in order of their *moment of inertia*, least to most. If any have the SAME moment, give them the same ranking number. **Explain your reasoning**.



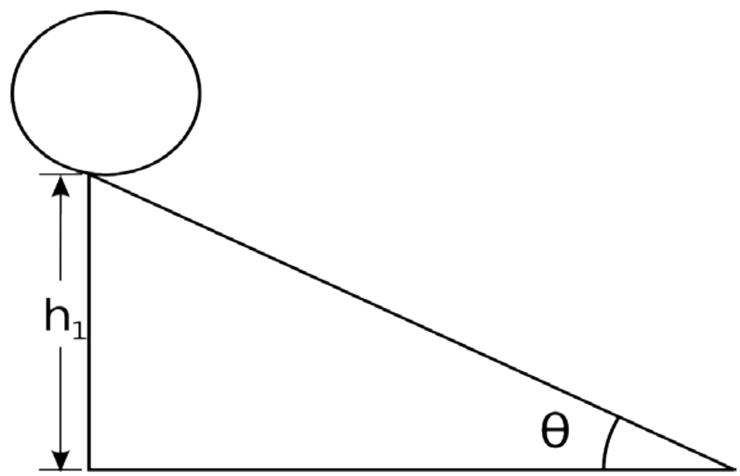
Consider a thin disk of mass M and radius R.

a) Calculate its moment of inertia, I, about an axis through its center of mass perpendicular to the surface of the disk.

b) Calculate its moment of inertia, I, about an axis through its center of mass parallel to the surface of the disk.

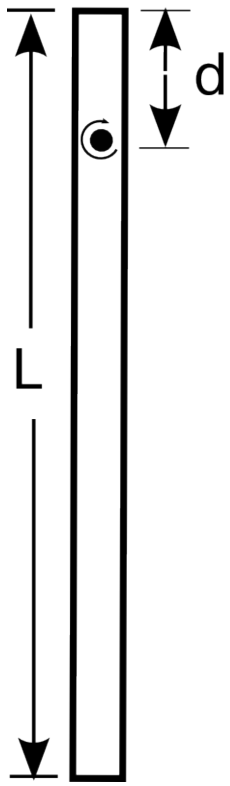
A rolling object with a radius *R*, mass *m*, and moment of inertia $I_{cm} = \frac{1}{2}mR^2$, starts from rest at the top of an incline plane of height *h* that makes an angle θ with the horizontal.

a) What is the linear velocity of disk at the bottom?
b) What is the angular velocity of the disk at the bottom?



A pendulum is constructed from a solid bar of length *L* and mass *M*. The bar is then hung from a pivot a distance d from the top of the bar. The bar is held at an angle θ from the vertical and released.

a) What is the bar's angular velocity as it passes vertical?
b) What is the velocity of the bottom tip of the bar as it passes vertical?
c) What is the velocity of the upper end of the bar as it passes vertical?
d) What is the velocity of the center of mass of the bar as it passes vertical?

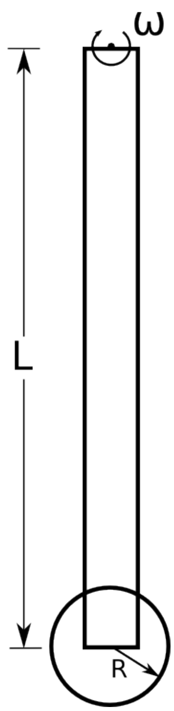


A clock pendulum is constructed from a solid bar of length *L* and mass *M* with a disk of radius *R* and mass *m*. The bar is then hung from a pivot at one end and the disk is attached to the opposite end, as in the picture below.

a) The moment of inertia of a uniform rod about an axis perpendicular to the rod through its center of mass is $I_{cm} = \frac{1}{12}ML^2$. Using the **Parallel Axis Theorem**, calculate the moment of inertia of the rod about one end.

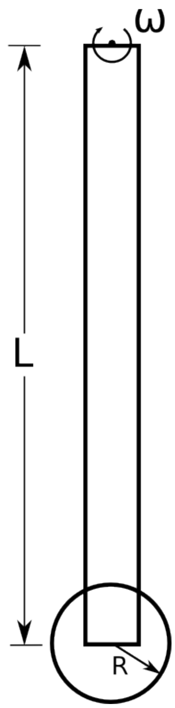
b) The moment of inertia of a disk about an axis perpendicular to its surface through its center of mass is $I_{cm} = \frac{1}{2}mR^2$. Using the **Parallel Axis Theorem**, calculate the moment of inertia of the disk when it's attached to the pendulum as shown in the picture below.

c) Using the **Principal of Superposition**, calculate the moment of inertia of the combined rod-disk system.



Consider, once again, the clock pendulum pictured below. The disk has a mass m and radius r and the bar has mass M and length L.

a) Calculate the center of mass of the combined bar-disk system *as measured from the axis of rotation*.
b) If the pendulum is pivoted so that it makes an angle θ with the vertical, what will the angular velocity be when $\theta = 0$?



A solid cylinder (radius = R, mass = M) rolls without slipping as it is pulled by a massless yoke attached to a string. The string goes over a frictionless pulley shaped as a solid disk (radius = R, mass = M) and is attached to a mass (m = M). What is the velocity of the system after the hanging mass has fallen a distance d?

a) What is the velocity of the hanging mass if the pulley is massless and frictionless

b) What is the velocity of the hanging mass if the pully is a flat disk with mass m and radius ½R.